

TERMINAL APPOINTMENT SYSTEM STUDY

Prepared for
Transportation Development Centre
of
Transport Canada

by
Roche Ltée, Groupe-conseil
and
Levelton Consultants Ltd.

March 2006

106-07485

TP 14570E

TERMINAL APPOINTMENT SYSTEM STUDY

by

Philippe Morais, Eng. – Roche Ltée, Groupe-conseil
Elisabeth Lord, Eng., P.Eng. M.Sc. – Levelton Consultants Ltd.

March 2006

NOTICES

This report reflects the views of the authors and not necessarily the official views or policies of the Transportation Development Centre of Transport Canada or the co-sponsoring organisations.

The Transportation Development Centre and the co-sponsoring agencies do not endorse products or manufacturers. Trade or manufacturers' names appear in this report only because they are essential to its objectives.

Since some of the accepted measures in the industry are imperial, metric measures are not always used in this report.

Un sommaire français se trouve avant la table des matières du présent rapport.

Transport
CanadaTransports
Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No. TP 14570E		2. Project No. 5554		3. Recipient's Catalogue No.	
4. Title and Subtitle Terminal Appointment System Study				5. Publication Date March 2006	
				6. Performing Organization Document No. 30986	
7. Author(s) Philippe Morais and Elisabeth Lord				8. Transport Canada File No. 2450-CP360/7	
9. Performing Organization Name and Address Roche Ltée, Groupe Conseil 630 René-Lévesque Blvd. West Suite 1500 Montreal, Quebec H3B 1S6 Levelton Consultants Ltd. 85 St. Charles West Suite 201 Longueuil, Quebec J4H 1C5				10. PWGSC File No. MTB-4-00969	
				11. PWGSC or Transport Canada Contract No. T8200-044512/001/MTB	
12. Sponsoring Agency Name and Address Transportation Development Centre (TDC) 800 René Lévesque Blvd. West Suite 600 Montreal, Quebec H3B 1X9				13. Type of Publication and Period Covered Final	
				14. Project Officer Ernst Radioff	
15. Supplementary Notes (Funding programs, titles of related publications, etc.) Co-sponsored by the federal Program of Energy Research and Development (PERD) of Natural Resources Canada (NRCan)					
16. Abstract The study reviewed programs and strategies currently applied at North American ports to accelerate cargo handling at ports and terminals aimed at reducing congestion, gate idling time, and greenhouse gas emissions (GHG). The study found that automation technologies, extended gate hours, and reservation appointment systems can be effective in reducing the overall truck idling time at terminals and limit GHG emissions associated with terminal drayage activities. A quantitative method was developed to assess the impact of port technologies and appointment systems to reduce GHG emissions. The report proposes a strategy to improve port/terminal operation efficiency and reduce emissions at Canadian ports. A comprehensive Canadian strategy would include policies, programs, regulation, air quality mitigation programs, and infrastructure improvements.					
17. Key Words Ports, terminals, containers, ITS, intelligent transportation systems, appointment systems, trucks, greenhouse gases, GHG, emissions, air quality, idling, queuing, congestion, Canadian applicability, reservation systems			18. Distribution Statement Limited number of print copies available from the Transportation Development Centre. Also available online at www.tc.gc.ca/tdc/menu.htm		
19. Security Classification (of this publication) Unclassified		20. Security Classification (of this page) Unclassified		21. Declassification (date) —	22. No. of Pages xxi, 102
				23. Price Shipping/ Handling	



Transports
Canada

Transport
Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. N° de la publication de Transports Canada TP 14570E	2. N° de l'étude 5554	3. N° de catalogue du destinataire		
4. Titre et sous-titre Terminal Appointment System Study		5. Date de la publication Mars 2006		
		6. N° de document de l'organisme exécutant 30986		
7. Auteur(s) Philippe Morais et Elisabeth Lord		8. N° de dossier - Transports Canada 2450-CP360/7		
9. Nom et adresse de l'organisme exécutant Roche Ltée, Groupe-conseil 630, boul. René-Lévesque Ouest Bureau 1500 Montréal (Québec) H3B 1S6 Levelton Consultants Ltd. 85, rue Saint-Charles Ouest Bureau 201 Longueuil (Québec) J4H 1C5		10. N° de dossier - TPSGC MTB-4-00969		
		11. N° de contrat - TPSGC ou Transports Canada T8200-044512/001/MTB		
12. Nom et adresse de l'organisme parrain Centre de développement des transports (CDT) 800, boul. René-Lévesque Ouest Bureau 600 Montréal (Québec) H3B 1X9		13. Genre de publication et période visée Final		
		14. Agent de projet Ernst Radloff		
15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.) Coparrainé par le Programme de recherche et développement énergétiques (PRDE) de Ressources naturelles Canada (RNCan)				
16. Résumé L'étude a consisté à examiner les programmes et stratégies actuellement mis en œuvre dans les ports et terminaux d'Amérique du Nord pour accélérer la manutention des marchandises et réduire ainsi la congestion, le temps de marche au ralenti des camions en attente aux barrières et les émissions de gaz à effet de serre (GES). Elle a permis de conclure que les technologies d'automatisation, l'allongement des heures d'ouverture des barrières et les systèmes de réservation/attribution de créneaux horaires peuvent effectivement réduire le temps global de marche au ralenti des camions aux terminaux et limiter les émissions de GES associées aux activités de factage à l'intérieur du terminal. Une méthode quantitative a été élaborée pour mesurer jusqu'à quel point les technologies d'opérations portuaires et les systèmes de réservation/attribution de créneaux horaires peuvent réduire les émissions de GES. Le rapport propose une stratégie pour accroître l'efficacité opérationnelle des ports/terminaux et pour réduire les émissions polluantes dans les ports canadiens. Une stratégie globale pour le Canada doit comprendre des politiques, des programmes, une réglementation, des programmes de préservation de la qualité de l'air et l'amélioration des infrastructures.				
17. Mots clés Ports, terminaux, conteneurs, STI, systèmes de transports intelligents, systèmes de réservation/attribution de créneaux horaires, camions, gaz à effet de serre, GES, émissions, qualité de l'air, marche au ralenti, mise en file d'attente, congestion, applicabilité au Canada, systèmes de réservation		18. Diffusion Le Centre de développement des transports dispose d'un nombre limité d'exemplaires imprimés. Disponible également en ligne à www.tc.gc.ca/cdt/menu.htm		
19. Classification de sécurité (de cette publication) Non classifiée	20. Classification de sécurité (de cette page) Non classifiée	21. Déclassification (date) —	22. Nombre de pages xxi, 102	23. Prix Port et manutention

ACKNOWLEDGEMENTS

Bay Area Air Quality Management District:

Mr. Ronald S. Pilkington, Supervising Air Quality Inspector
Mr. Tony Gambardella, Principal Air Quality Specialist

Port Authority of Los Angeles – Environmental Department:

Ms. Shokoufe Marashi, Environmental Specialist
Mr. Kevin Maggay, Environmental Specialist

Port of Los Angeles – Trans Pacific Container Service Corporation (TraPac):

Mr. Frank Pisano, Vice-President
Mr. Daryl Hoshide, Terminal Operations Manager

Port of Los Angeles – Maersk Sealand:

Ms. Konstantine, Director of Communications

Port Authority of Long Beach – Trade and Maritime Services:

Mr. Donald Snyder, Director

Centre for International Trade and Transportation (CITT):

Mr. Thomas J. O'Brien, Director of Research

EModal:

Mr. Gunnar Gose, Director Sales and Marketing

Marine Terminals Corporation (MTC):

Mr. Steven G. Lautsch, Executive Vice President – Business Development

Port of Long Beach – Stevedoring Service of America Terminal (SSAT):

Mr. Pieter Suttorp, General Manager
Mr. Alan Bates, Terminal Manager

Port of Oakland – Marketing Division:

Mr. Dan Westerlin, Special Assistant to the Executive Director

Port of Oakland – Marine Division:

Mr. Christopher Peterson, Wharfinger

Port of Oakland – Environmental Department and Air Quality MD Enforcement:

Mr. Jeffrey R. Jones, Environmental Compliance Supervisor
Mr. Tim Leong, Port Environmental Scientist

Port of Oakland – Seaside Transportation Services (STS):

Mr. Chris May, Terminal Manager

Seattle Seaport:

Mr. Kent Christopher, General Manager Containers

Seattle Seaport – Stevedoring Service of America Terminal (SSAT):
Mr. Lee MacGregor, General Manager

Port of Vancouver – Trade Development Container:
Mr. Brian T. Yamaguchi

Port of Vancouver – Shore Operations:
Mr. Bob Hayter, Manager
Mr. Doug Mills, Coordinator

Port of Vancouver – Environmental Programs:
Ms. Alicia Blancarte, Director
Ms. Christine Rigby, Environmental Specialist – Air Emissions

Port of Vancouver – Terminal Systems Inc. (TSI):
Mr. Nick Vancic, Operations Superintendant

and the support and advice of Mr. Ernst Radloff, Pierre Bolduc and Raynald Ledoux of the Transportation Development Centre of Transport Canada, are gratefully acknowledged.

PROJECT TEAM

Philippe Morais, Eng. – Project Leader
Elisabeth Lord, Eng., P. Eng., M.Sc.
Ana Booth, P.Eng. Ph.D.

EXECUTIVE SUMMARY

Ports serve as the gateway for goods destined for world markets. However, most major North American ports face significant delays in moving cargo due to capacity constraints of ports, road and rail networks. These factors all have an impact on moving containers from the terminal to the hinterland. This is primarily due to the increased trade between North American and Asian markets. This results in highly congested ports and given the limited land available for expansion leaves terminal operators with little option but to improve their current productivity.

In addition, port activities have also been identified to be a major source of air pollution. Diesel exhaust emissions from ships, railroads, trucking and terminal cargo handling equipment contribute to respiratory and cardiovascular diseases. Ports continuously face challenges in managing environmental and economic issues. Short haul trucking or drayage is an integral element of intermodal freight transportation and a key component in the logistic supply chain. The number of trucks operating in the urban environment is on the increase and contributes to the rise of GHG emissions.

Increases in productivity and efficiencies have been obtained through the implementation of information and Internet technologies. The ability of port information systems to provide advanced freight scheduling, appointment and container tracking information to trucking companies and container terminals can provide substantial benefits to the port community at large as port terminals have contributed to reduced emissions in the urban environment. These benefits are the alleviation of congestion and delays on roads and at the terminal gate, fuel savings and reduction of vehicle GHG emissions.

A study was carried out assessing the impact of terminal gate reservation systems, automation technologies, extended gate hours and other strategies for improving cargo velocity at ports and terminals in order to reduce congestion, delays and GHG emissions. A review of North American container ports highlighted the fact that west coast ports are leaders in environmental legislation and programs, and in the implementation of information and automation technology to enhance terminal productivity.

Solutions for improving terminal productivity and reducing congestion are centred on implementing technologies and Internet based cargo information systems. Specific solutions targeting truck idling involve the integration of appointment systems and extended gate hours. Data from case studies show that extended gate hours and gate reservation systems implemented at the Port of Vancouver were effective in reducing truck emissions.

These approaches were assessed to observe their respective benefits of reducing truck idling at gates and increasing the truck turn-around time. The reduction of truck idling time is an element of an overall strategy to reduce vehicle emissions outlined in this report. Reducing gate congestion increases truck turnaround time and customer satisfaction.

This study reviews programs and technologies currently applied primarily at North America west coast ports. It also presents data related to gate, yard, quay and drayage

truck operations. The study also looks at the challenges faced by terminals in dealing with stevedore unions, trucking companies, and the cultural and language barriers faced by drivers. West Coast terminals primarily rely on short haul container drayage and to a lesser extent intermodal rail as a means of moving containers from the terminal to inland distribution centres.

A quantitative method to assess the impact of port technologies and appointment systems on reducing GHG emissions was developed. The method calculates greenhouse gases generated from truck idling during the total gate-to-gate truck itinerary. The benefits in increasing the overall terminal efficiency of these two approaches are described in this report. The study indicates that the implementation of automated technologies and appointment systems can be effective in reducing the overall truck idling time at terminals. The study also quantifies and characterises the emission reductions potentially achievable at terminals with the integration of new terminal technologies and gate reservation systems.

The report proposes a strategy to improve port/terminal operations efficiency and reduce emissions at Canadian ports. A comprehensive Canadian strategy would include policies, programs, regulation, air quality mitigation programs, and infrastructure improvements. The introduction of gate appointment systems, extended gate and new automation technologies offers the best promise to more efficient operations.

SOMMAIRE

Les ports servent de lieux de transit aux marchandises destinées aux marchés mondiaux. Mais la plupart des grands ports nord-américains connaissent d'importants retards dans l'acheminement du fret, en raison de leurs propres contraintes de capacité et de celles des réseaux routier et ferroviaire. Ces facteurs combinés retardent l'acheminement des conteneurs du terminal vers l'arrière-pays. Cette lourdeur est principalement due à l'essor du commerce entre les marchés nord-américain et asiatique. On assiste donc à une forte congestion des ports et comme la rareté des terrains limite les projets d'expansion, les exploitants de terminaux n'ont d'autre choix que d'améliorer leur productivité.

Par ailleurs, les activités portuaires sont reconnues comme une importante source de pollution atmosphérique. Les émissions diesel des navires, des trains, des camions et des engins de manutention du fret contribuent aux maladies respiratoires et cardiovasculaires. La gestion des enjeux environnementaux et économiques pose continuellement des défis aux ports. Le camionnage sur de courtes distances, ou factage, est une partie intégrante du transport intermodal de marchandises, et un maillon crucial de la chaîne logistique d'approvisionnement. Le nombre de camions circulant en milieu urbain est en hausse et cela contribue à l'augmentation des émissions de GES.

La mise en œuvre de technologies de l'information et d'Internet a mené à une hausse de productivité et d'efficacité. Des systèmes d'information capables d'offrir aux entreprises de camionnage et aux terminaux de conteneurs la possibilité de réserver à l'avance des heures de chargement/déchargement et de faire le suivi de leurs conteneurs peuvent entraîner des avantages substantiels pour toute la collectivité portuaire, voire pour l'environnement urbain. Ces avantages sont la diminution de la congestion et de l'attente sur les routes et à l'entrée des terminaux, les économies de carburant et la réduction des GES rejetés par les véhicules.

Une étude a été menée pour évaluer l'efficacité des systèmes de réservation/attribution de créneaux horaires aux terminaux, des technologies d'automatisation, de l'allongement des heures d'ouverture des barrières et d'autres stratégies, à accélérer le transit des marchandises dans les ports et terminaux, et à réduire ainsi la congestion, les retards et les émissions de GES. Une revue des ports de conteneurs nord-américains a mis en lumière le rôle de leader joué par les ports de la côte ouest en matière de législation et de programmes environnementaux, et dans la mise en œuvre de technologies de l'information et d'automatisation pour accroître la productivité des terminaux.

Les solutions pour améliorer la productivité des terminaux et réduire la congestion sont axées sur la mise en œuvre de technologies et de systèmes d'information sur les marchandises fondés sur Internet. D'autres solutions, qui visent plus précisément à diminuer le temps de marche au ralenti des camions, consistent à mettre en place des systèmes de réservation/attribution de créneaux horaires et à allonger les heures d'ouverture des barrières. Les données issues d'études de cas montrent que les heures d'ouverture prolongées et le système de réservation mis en place au Port de Vancouver ont été efficaces à réduire les émissions des camions.

Ces deux approches ont été comparées sous l'angle de leurs avantages respectifs aux chapitres de la réduction du temps de marche au ralenti des camions aux barrières et du temps de rotation des camions. La réduction du temps de marche au ralenti fait partie d'une stratégie globale de réduction des émissions des véhicules décrite dans le rapport. Quant à la réduction de la congestion aux barrières, elle mène à une amélioration du temps de rotation des camions et de la satisfaction des consommateurs.

Cette étude passe en revue les programmes et les technologies présentement appliqués dans les ports situés pour la plupart sur la côte ouest de l'Amérique du Nord. Elle présente aussi les données sur les opérations aux barrières, aux triages, aux quais, et sur le factage. L'étude jette également un regard sur les défis auxquels font face les terminaux dans leurs négociations avec les syndicats de débardeurs et les entreprises de camionnage, et sur les obstacles culturels et linguistiques auxquels se heurtent les conducteurs. Les terminaux de la côte ouest utilisent surtout le factage de conteneurs sur de courtes distances et, dans une moindre mesure, le rail intermodal pour transporter les conteneurs du terminal vers les centres de distribution intérieurs.

Une méthode quantitative a été élaborée pour évaluer l'effet des technologies d'opérations portuaires et des systèmes de réservation/attribution de créneaux horaires sur la diminution des émissions de GES. La méthode calcule les gaz à effet de serre rejetés par les camions en marche au ralenti pendant tout leur parcours, de leur entrée dans le port à leur sortie. Le rapport décrit l'efficacité respective des deux approches à augmenter l'efficacité globale du terminal. L'étude indique que la mise en oeuvre de technologies automatisées et de systèmes de réservation/attribution de créneaux horaires peut effectivement mener à une réduction du temps global de marche au ralenti des camions aux terminaux. De plus, elle chiffre et caractérise les réductions d'émissions envisageables par suite de l'intégration de nouvelles technologies d'opérations portuaires et de systèmes de réservation de barrières.

Le rapport propose une stratégie pour accroître l'efficacité opérationnelle des ports/terminaux et pour réduire les émissions polluantes aux ports canadiens. Une stratégie globale pour le Canada doit comprendre des politiques, des programmes, une réglementation, des programmes de préservation de la qualité de l'air et l'amélioration des infrastructures. La mise en place d'un système de réservation de barrières, d'heures d'ouverture des barrières prolongées et de nouvelles technologies d'automatisation est le meilleur gage d'opérations plus efficaces.

TABLE OF CONTENTS

1	INTRODUCTION.....	1
2	BACKGROUND	3
3	METHODOLOGY	5
3.1	Overview of Port and Terminal Technologies for Operation Systems and Existing Environmental Programs	6
3.2	Technical Evaluation of Technologies and Terminal Operating Systems	7
3.3	Development of a Canadian Strategy for Reduction of GHG Emissions.....	7
3.4	Conclusion and Recommendations.....	8
4	LITERATURE REVIEW.....	9
4.1	Technologies and Terminal Operation System (TOS).....	10
4.1.1	Sector Activities	10
4.1.2	Cargo Handling Equipment.....	11
4.1.3	Automation Technologies	12
4.1.4	Port Community Information System	15
4.2	Proprietary Terminal Information Systems	20
4.3	Terminal Operating Systems (TOS)	21
4.4	Terminal Container Positioning and Inspection Systems	23
4.5	Environment	24
4.5.1	Legislation and Other Programs.....	24
4.5.2	Overview of Canadian Initiatives in the Marine Sector	31
4.5.3	Truck Idling Behaviour and Influences on Emissions	31
4.5.4	Vehicle Emissions Calculation Models	32
5	TELEPHONE INTERVIEWS AND SITE VISITS	37
5.1	Interviews	37
5.2	Site Visits.....	37
6	FINDINGS FROM REVIEW, INTERVIEWS AND VISITS	47
6.1	Terminal Appointment System	47
6.2	Pier Pass Program	48
6.3	Other Environmental Programs.....	49
7	CANADIAN STRATEGY FOR REDUCTION OF GHG AT TERMINALS	51
7.1	Context	51
7.2	Estimated Current Travel Time.....	51
7.2.1	Port of Montreal's CAST Terminal (2005).....	54
7.2.2	Los Angeles TraPac Terminal (2005).....	55
7.2.3	Oakland STS Terminal (2005).....	57
7.2.4	Overview of the Current Situation.....	57
7.3	Estimation of Greenhouse Emissions – Current Scenario	58
7.3.1	Calculation Methodology	58
7.3.2	Approach to Reducing Greenhouse Gas Emissions	59
7.3.3	Approach and Greenhouse Gas Emission Factors	60
7.3.4	Calculation of GHG Emissions at Terminals – Current Situation.....	64
7.3.5	Determining Long/Short Idling	64

7.4	Impacts of Technologies on Reducing GHG Emissions.....	65
7.4.1	Impact of Technologies on Time Delays.....	65
7.4.2	GHG Emission Reductions	67
7.5	Projected Impact of Technologies on GHG Emissions.....	69
7.5.1	Include Current Co-ordinates (gate moves, idling times).....	70
7.5.2	Technology Selected and Determining the New Curve	70
7.5.3	Determination of Waiting Time	71
7.5.4	Greenhouse Gas Emissions Calculations Combined with the Strategy	72
7.6	Canadian Applicability	74
7.6.1	Context	74
7.6.2	Actual Status at the Ports of Montreal (POM) and Vancouver (POV).....	75
7.6.3	Canadian Applicability	85
8	CONCLUSION	89
9	RECOMMENDATIONS	95
10	REFERENCES.....	97
11	BIBLIOGRAPHY	99

LIST OF FIGURES

Figure 4-1	Typical Gate Sector	10
Figure 4-2	Typical Yard Sector	11
Figure 4-3	Typical Quay Sector	11
Figure 4-4	Logo of the Anti-Idling Campaign	28
Figure 7-1	Typical Container Truck Path at Container Terminal.....	52
Figure 7-2	Time Space Curve of a Truck Route	53
Figure 7-3	Emissions per Truck During Short Idling	63
Figure 7-4	Emissions per Truck During Long Idling	63
Figure 7-5	Impact of Technologies at TRAPAC and STS Terminals	69
Figure 7-6	Montreal CAST – Current Positioning (Waiting Time/Gate Moves Per Day)	70
Figure 7-7	Montreal CAST – Extrapolation Curve	70
Figure 7-8	GHG Emission Factors for Long/Short and High/Low Idling	73

LIST OF TABLES

Table 4-1	North American Ports with Busiest Container Activities	9
Table 4-2	OCR Applications	13
Table 4-3	GPS Applications.....	13
Table 4-4	RFID Applications.....	13
Table 4-5	Electronic Seal Applications	14
Table 4-6	Weigh-In-Motion (WIM) Applications	14
Table 4-7	CCTV Camera Applications.....	14
Table 4-8	Variable Message Sign (VMS) Applications	15
Table 4-9	Bar Code Readers and Mounted Data Collection Computer Applications	15
Table 4-10	State and Municipal Idling Regulations	25
Table 4-11	Emission Calculations for Truck Idling Before and After the Lowenthal Bill (2003)	27
Table 4-12	The Two Canadian Regulatory Authorities of the Marine and Transportation Sectors' Emissions	31
Table 4-13	Idling Emission Factors Developed by University of California Davies ...	34
Table 4-14	CO ₂ Idling Emission Factors Published by CEPA (CARB, 2003)	35
Table 4-15	CO ₂ Idling EFs Published by the U.S. EPA	35
Table 5-1	List of Participating Stakeholders – Interview Process.....	38
Table 5-2	Visit Schedule, Contacts and Highlights.....	39
Table 6-1	Air Quality Mitigation Actions Taken by Ports.....	49
Table 7-1	Tcurrent Waiting Time at Terminals Visited.....	58
Table 7-2	Global Warming Potentials and Atmospheric Lifetimes.....	59
Table 7-3	Emission Factors Used to Estimate GHG Emissions During Long Idling	62
Table 7-4	Emission Factors Used to Estimate GHG Emissions During Short Idling.....	62
Table 7-5	Choices of Emission Factors Parameters for Each Scenario.....	64
Table 7-6	Influence of Temperature on Climate Devices and On-board Accessories	65
Table 7-7	GHG Emission Estimates for Each Scenario	65
Table 7-8	TraPac – Current and Past Waiting Time (truck idling)	66
Table 7-9	TraPac – Current and Past Gate Movement	66
Table 7-10	STS – Current and Past Gate Movement.....	66
Table 7-11	STS – Current and Past Gate Movement.....	67
Table 7-12	Choices of Emission Factors Parameters for Each Scenario.....	67
Table 7-13	Assumption of the Use of On-board Accessories during Long Idling	68
Table 7-14	Past GHG Emissions.....	68
Table 7-15	Comparison of Past/Current GHG Emissions	68
Table 7-16	CAST Montreal – Extrapolation of Data for Gate Moves and Waiting Times	71
Table 7-17	GHG Emission Rates and Parameters.....	73
Table 7-18	Comparison of Current/Future GHG Emissions	74
Table 7-19	Strategic Components and Description	75
Table 7-20	Current Status at POM and POV.....	76

ACRONYMS

APS	Auxiliary Power System
ATCM	Airborne Toxic Control Measure
BAAQMD	Bay Area Air Quality Management District
CARB	California Air Resource Board
CBIP	Commercial Building Incentive Program
CH ₄	Methane
CHE	Cargo Handling Equipment
CO ₂	Carbon Dioxide
CO ₂ E	Carbon Dioxide Equivalence
CTO	Container Terminal Operation
DOE	Department Of Energy (US)
EC	Environment Canada
EDI	Electronic Data Interchange
EIR	Equipment Interchange Receipt
EPA	Environmental Protection Agency (US)
FIRST	Freight Information Real-Time System for Transport
FTP	Federal Test Procedure
GHG	Greenhouse Gas
GPS	Global Positioning System
GVRD	Greater Vancouver Regional District
GWP	Global Warming Potential
HDDV	Heavy Duty Diesel Vehicle
HDVIP	Heavy-Duty Vehicle Inspection Program
IMO	International Maritime Organization
ITS	Intelligent Transportation Systems
Kg	Kilograms
Lb	Pounds
Levelton	Levelton Consultants Ltd.
MAS	Multi-Agent Sytem
MGN	Maritime Global Net
NO ₂	Nitrous Dioxide
OCR	Optical Character Recognition
PSIP	Periodic Smoke Inspection Program
RDT	Radio Data Terminals
Roche	Roche Group Ltd
RPM	Revolution per Minute
SCAQMD	South Coast Air Quality Management District
SECA	Sulphur Emission Control Association
TC	Transport Canada
TCEA	Texas Commission on Environmental Quality
TDC	Transportation Development Centre
TEAM	Technology Early Action Measures
TERP	Texas Emission Reduction Program
Tonnes	Metric Tonnes
TOS	Terminal/Port Operation Systems
VPA	Vancouver Port Authority
US	United States
VCY	Virtual Container Yard

GLOSSARY

Auxiliary Power System (APS): A power source from the shore based electrical grid that provides electricity to a vessel in lieu of ship based auxiliary generators.

Bobtail: A tractor operating without a chassis (trailer).

Canada's Climate Change Plan: Canada's strategy to honour the Kyoto commitments while improving competitiveness in a sustainable economy.

Chassis: A wheeled flat bed or a trailer constructed to accommodate containers moved over the road.

Class 6, 7 or 8 Diesel-Powered Trucks: Vehicles that have a gross vehicle weight of 19,501 lb or more (up to 60,000 lb) that are powered with diesel fuel.

CO: Carbon monoxide is a colorless, odorless, tasteless and poisonous gas. It is a product of incomplete combustion of hydrocarbon-based fuels and is emitted directly from automobile tailpipes. CO can have a significant impact on human health. It enters the bloodstream through the lungs and forms carboxyhemoglobin, a compound that inhibits the blood's capacity to carry oxygen to organs and tissues.

CO₂: Most important of the greenhouse gases released by human activities. It is the main contributor to climate change because of the quantities released – especially through the burning of fossil fuels.

Container: A container is a box, rectangular in shape and typically made of steel, and designed to carry goods from door to door without the contents being handled. Containers have doors that open at the end to allow forklifts to be driven inside to load and unload goods. Containers are either 20 foot or 40 foot in length to allow the transfer of the same container from one mode of transport to another. There are several types of containers depending upon the cargo they carry, eg. Refrigerated containers called 'reefers' carry frozen or chilled goods.

Container Terminal: An area designated for the stowage of cargo in containers. Usually accessible by truck, railroad and marine transportation, the terminal is where containers are picked up, dropped off, maintained and stored.

Drayage: Short-haul motor vehicle operators engaged in picking-up or delivering containers to marine terminals.

Efficiency: The use of resources that, with a given set of inputs, produces maximum outputs or produces a given output with a minimum set of inputs.

Electronic Data Interchange (EDI): EDI is the electronic processing and transfer of data contained in a shipping manifest between shipping lines and agencies, port managers, stevedores and other agencies in the logistics chain.

Forty Foot Equivalent Unit (FEU): This is a unit of measurement equivalent to one 40-foot shipping container. Two 20-foot containers comprise one FEU. This measurement is used to quantify the container capacity of a ship.

Gantry Crane: This is a type of crane with a wide span, used for moving and stacking containers. Such cranes operate by straddling several rows of containers. They can be either rail-mounted or rubber tired.

Gate: Entry and Exit to terminal.

Global Warming Potential: Approximate the amount of heat-trapping potential for any given GHG within the atmosphere over a 100 year period.

Greenhouse Gases: Greenhouse gases are any type of gas, but especially carbon dioxide, that contributes to the greenhouse effect.

Harbour Vessels: Harbour vessels such as tugboats, commercial fishing vessels, dredge, etc. that remain in close proximity of the port and are primarily used by terminals and ports.

Heavy-Duty Diesel Trucks: Vehicles of 8,501 lb gross vehicle weight and higher that are equipped with heavy-duty engines and that use diesel fuel.

Heavy-Duty Truck: Vehicles of 19,501 lb gross vehicle weight and higher that are equipped with heavy-duty engines. Examples of heavy-duty vehicles include large pick ups, buses, delivery trucks, recreational vehicles (RVs), and semi trucks.

Intermodal: Freight movement of containers by ships, trucks or rail.

Internal Movement Vehicle: Heavy-haul truck used to move containers between facilities within the port.

Just-in-Time (JIT): Cargo or components that must be at a destination at the exact time needed. The container or vehicle is the movable warehouse.

Live Load: A situation in which the equipment operation stays with the trailer or boxcar while being loaded or unloaded.

Manifest: A manifest is a document containing a full list of a ship's cargo. A copy of the manifest is lodged with the Customs authorities at the port of loading. Another copy is lodged at the discharge port, with another copy going to the ship's agent so that the unloading of the ship may be planned in advance.

Methane (CH₄): Greenhouse gas composed of one carbon and four hydrogen atoms (CH₄) with a global warming potential of 21.

Moves/Movement: This term refers to receipt or delivery of containers at the gate, as well as loading or unloading of containers or chassis to inland carrier's equipment that is specifically located within the Container Yard and is not associated with a throughput move. This service also includes container stacking, un-stacking, loading or unloading of

inland carrier's equipment that is not held in a specified yard location or is not being held for vessel dispatch.

Nitrous Oxide (N₂O): Greenhouse gas composed of two nitrogen and one atom of oxygen (N₂O) with a global warming potential of 310.

NO_x: Nitrogen oxides – these include the gases nitrogen oxide (NO) and nitrogen dioxide (NO₂). NO_x is formed primarily from the liberation of nitrogen contained in fuel and nitrogen contained in combustion air during combustion processes. NO_x can have adverse effects on human health or the environment. NO₂ itself can cause adverse effects on respiratory systems of humans and animals, and damage to vegetation. NO_x also contribute to acidification of aquatic and terrestrial ecosystems, are contributor to the secondary formation of breathable particulate matter (PM_{2.5}) and NO₂ is one of the two primary contributing pollutants, along with volatile organic compounds (VOCs), to the formation of ground-level ozone formation.

On-Dock Rail: Direct shipside rail service. Includes the ability to load and unload containers/breakbulk directly from rail car to vessel.

Owner-Operator: Trucking operation in which the owner of the truck is also the driver.

Pier-Pass: A not for-profit company created by terminal operators to reduce congestion and improve air quality in and around the ports of LB and LA.

Port Authority: State or local government that owns, operates, or otherwise provides wharf, dock, and other terminal investments at ports.

PM: Particulate matter (PM) consists of airborne particles in solid or liquid form. The size of PM particles largely determines the extent of environmental and health damage caused. For this reason, PM is classified in different sizes:

- 1 **Total Particulate Matter (TPM):** Airborne particulate matter with an upper size limit of approximately 100 micro metre (µm) in aerodynamic equivalent diameter;
- 2 **PM₁₀:** Particulate Matter <10 microns – airborne particulate matter with a mass median diameter less than ten µm;
- 3 **PM_{2.5}:** Particulate Matter < 2.5 microns – airborne particulate matter with a mass median diameter less than 2.5 µm.

Numerous studies have linked PM to aggravated cardiac and respiratory diseases such as asthma, bronchitis and emphysema and to various forms of heart disease. PM can also have adverse effects on vegetation and structures, and contributes to visibility deterioration and regional haze.

Radio Frequency Identification (RFID): A form of wireless communication device that lets users relay information via electronic energy waves from a terminal to a base station, which is linked in turn to a host computer. The terminals can be placed at a fixed station, mounted on a forklift truck, or carried in the worker's hand. The base station contains a transmitter and receiver for communication with the terminals. When

combined with a tag system for identifying inventory items, a radio-frequency system can relay data instantly, thus updating inventory records in so-called "real time".

Reach Stacker: A reach stacker is a type of forklift with a telescopic boom and top lift attachment used for lifting and stacking containers. Its design enables to reach beyond the first row to pick up a container.

Reliability: Refers to the degree of certainty and predictability in travel times on the transportation system. Reliable transportation systems offer some assurance of attaining a given destination within a reasonable range of an expected time. An unreliable transportation system is subject to unexpected delays, increasing costs for system users.

Roll-on/Roll-off (ro/ro) Cargo: Wheeled cargo, such as automobiles, or cargo carried on chassis that can be rolled on or off vehicles without using cargo-handling equipment.

Side Loader: A lift truck fitted with lifting attachments operating on one side for handling containers.

Spreader: Equipment designed to lift containers by their corner casters.

Supply Chain: Starting with unprocessed raw materials and ending with final customer using the finished goods.

Terminal Operating Systems: Integrated operations allowing the receipt, transit storage and marshalling of cargo, the loading and unloading of ships and the manifesting and forwarding of cargo.

TEU: Twenty-foot equivalent unit, a standard size intermodal container Twenty-foot Equivalent Unit (TEU) – The 8-foot by 8-foot by 20-foot intermodal container is used as a basic measure in many statistics and is the standard measure used for containerized cargo.

Throughput: The term "throughput" denotes the single movement of a container between vessel stowage and inland intermodal carrier.

Ton: Short ton unit – A unit of weight equal to 20 hundredweight. In the United States, there are 100 lb in the hundredweight and exactly 2000 lb (907.185 kg) in the ton. In Britain, there are 112 lb in the hundredweight and 2240 lb (1016.047 kg) in the ton. To distinguish between the two units, the British ton is called the long ton and the American one is the short ton.

Tonne (t): A metric unit of mass equal to 1000 kg. Also called the metric ton.

Transaction: An activity and associated process involving the pick up or delivery of containers at intermodal terminals.

Turn Around Time (Trucks): The time elapsed between loading of truck and its return for reloading at point of origin.

VOC: Volatile organic compounds are carbon-containing gases and vapours such as gasoline fumes and solvents (but excluding carbon dioxide, carbon monoxide, methane, and chlorofluorocarbons). Many individual VOCs are known or suspected of having direct toxic effects on humans, ranging from carcinogenesis to neurotoxicity. A number of individual VOCs (e.g. benzene, dichloromethane) have been assessed to be toxic under the Canadian Environmental Protection Act, 1999 (CEPA 1999). The more reactive VOCs combine with nitrogen oxides (NO_x) in photochemical reactions in the atmosphere to form ground-level ozone, a major component of smog.

1 INTRODUCTION

Ports serve as the gateway for goods destined for world markets. World trade is expected to grow proportionally to our economy. The efficient movement of goods is, therefore, a key element in the increase of trade. However, most major North American ports face significant delays in moving goods due to capacity constraints of ports, road and rail networks. These factors all have an impact on moving containers from the terminal to the hinterland. However, while the increasing trade flowing through the nation is good for the economy, the negative aspects of port operations cannot be denied. Air, water and soil quality is highly impacted by port activities. Port activities have also been identified to be a major source of air pollution. Diesel exhaust emissions from ships, railroads, trucks and terminal cargo handling equipment contribute to cancer, cardiovascular and respiratory diseases.

Shippers need to deliver goods in a timely and efficient manner to obtain door to door and just-in-time delivery. This requires the use of on-road diesel trucks to move containerized cargo into and out of ports. Most trucks serving ports are operated by independent owner operators or are part of a short haul drayage fleet. Port drayage operators pick up containers at the port and deliver them at an inland distribution centre outside the port. The port fleet is typically much older than the long-haul trucking fleet, which distributes the cargo across the country. Consequently, these vehicles have higher emission levels and, therefore, the reduction of wait time at idle is critical in order to reduce pollution. The concentration of trucks at terminal gates to move the growing container volume creates long lines of idling vehicles. Both from an environmental and operational perspective this poses a problem.

West coast terminals primarily rely on short-haul container drayage and to a lesser extent intermodal rail as a means of moving containers from the terminal to inland distribution centres. The efficiency of container drayage operations is affected by import/export split, empty container moves, grounded versus wheeled operations, gate hours of operation, travel distances, intermodal mode split rail/truck. This study looks at the benefits resulting from the implementation of terminal automation (at the gate, at the quay and within the yard) and information technologies such as a trucker appointment system, for improving container truck velocity, thereby reducing congestion, delays and greenhouse gas (GHG) emissions at ports and terminals. The report also presents data related to gate, yard, quay and drayage truck operations.

Based on a review of current practice at major container terminals, an attempt was made to transfer the lessons learned and experience gained by the west coast ports to the Canadian context. This study reviews programs and technologies currently applied primarily at North America west coast ports in order to develop a Canadian strategy to reduce the impact of GHG associated with terminal drayage activities. An evaluation of the application of current technologies and programs then led to the identification of parameters defining the context and applicability in which the operational programs (technology and environmental) were developed.

2 BACKGROUND

Worldwide container traffic moving through the ports has experienced a phenomenal increase in volume in the last few years averaging about 12% annually. This increase in volume is directly linked to the growth in world trade. As a result of the increase in trade (especially cargo growth from Asia to North America and Europe), world containership capacity will rise by 12.7%. This increase in capacity is reflected in deployment of 79 new post-panamax vessels of greater than 6000 TEU. The largest post-panamax vessels now exceed 8000TEU. This forces shipping lines to call at fewer ports and unload a greater number of containers to maximize the efficiency of these large vessels. This contributes to added pressure on landside transportation system to increase efficiency and on terminals to process the containers. Ports require a faster turnaround and achieve greater container throughput (defined as efficiency and speed of moving goods through the transport chain) to cope with the increased container growth. Ports have invested in equipment modernization and infrastructure improvements to enhance productivity and increase throughput in order to offer their clients fast, reliable, and economical cargo handling.

With the increased volume of containerized freight ports and terminals are facing capacity and infrastructure problems associated with low productivity and congestion. These are not only linked to the ports and terminals but also to the intermodal carriers. Both motor carriers and intermodal rail operators are partly responsible for congestion and lack of capacity, which impacts the efficiency and reliability of service. It is becoming evident that landside access to ports and terminals is one of the key factors affecting productivity of intermodal operations.

Ports related transportation activities are major sources of emissions and contribute greatly to regional air quality levels. Studies show that ocean-going vessels are the primary sources of pollutants in regional sources (Levelton 2003a). Moreover, marine vessels are said to be the largest contributors in the future for regional air emissions e.g. Greater Vancouver Regional District (Levelton 2003b). Because of the magnitude of their port related emissions, port authorities have undertaken numerous initiatives for assessing and mitigating their air emissions.

In Canada, the Vancouver Port Authority has been proactive in formulating an integrated emissions program as a way to minimize the impact of their activities on the environment. The program covers the entire transportation supply chain serving the port and covers marine vessels terminal operations, railroads and trucking. In this context, minimizing the time trucks waiting at the gate and in the yard helps to reduce emissions associated with idling vehicles.

The program comprises a number of initiatives such as generating accurate emissions inventories, regional, implementation of emission reduction technologies, operational efficiency improvements and ultimately legislation and regulation.

In the United States, the EPA has implemented a clean ports program designed to reduce emissions from diesel engines at ports. The program aims to reduce pollution caused by diesel emissions through:

- Strategies to increase operational efficiencies, enhanced use of IT and gate automation improvements to avoid long periods of idling and anti-idling policies for trucks and equipment to reduce pollution; and
- Technological solutions to retrofit and replace equipment, trucks and vessels and the use of cleaner fuel.

Emission inventories help ports analyse the environmental problem and plan future operations with a reduced environmental impact. Inventories can improve perceptions towards the nature and magnitude of port-wide mobile emission sources. Most ports realise that emissions from container trucks idling at terminals are among the five major emission sources in the ports. These five major sources include:

- Ocean ship carriers;
- Harbour vessels;
- Cargo handling equipment (cranes, reach stackers, forklifts, rubber tired gantry (RTG) cranes, top handlers, etc.);
- Trains; and
- On-road trucks.

Several ports have gone through the exercise of carrying out emission inventories to provide baseline information and facilitate the assessment of mitigation program efficiencies.

3 METHODOLOGY

This project outlines a Canadian strategy for reducing intermodal freight transportation GHG, with a specific focus on container truck movements to and from terminals. These goals could be achieved through the implementation of terminal technologies, such as gate appointment systems for motor carriers and the application of gate automation technology. The implementation of IT and gate technologies can help to improve the interaction and integration of vehicles, operators and infrastructures in the transfer of goods.

The project involved a literature review, and a survey followed by on-site visit and interview with the respective port stakeholders. The review included:

- Port and terminal activities;
- Port and terminal technologies and information systems; and
- Environmental legislation and programs.

The following sections outline the methodology used to assess the implementation of port and terminal technologies. The study has focused on west coast port operations given their progress in environmental programs and implementation of terminal automation technologies. Also, a competitive environment existing at East Coast ports limited the amount of information obtainable on terminal operations.

Terminal automation technology and terminal operation systems were then assessed for their efficiency and their feasibility to reduce GHG. This analysis allowed structuring the data, and analysing terminal activities and operation systems efficiencies. The study also addresses the challenges faced by terminals in dealing with stevedore unions, trucking companies, and the cultural and language barriers faced by drivers.

This study examines the potential for GHG reductions in intermodal freight transportation area; specifically on-road trucks engaged in the transport of containers between marine terminals and inland distribution centres. Opportunities exist to reduce GHG in intermodal freight transportation such as terminal/gate management; improved gate clearance and cargo processing; and optimization of truck traffic into and out of terminals.

An attempt was made to transfer the lessons learned and experience gained by the west coast ports and to develop a strategy tailored for the Canadian context to reduce the impact of GHG associated with terminal drayage activities. An evaluation of the application of current technologies and programs then led to the identification of parameters defining the context and applicability in which the operational programs (technology and environmental) were developed.

The integration of both terminal management and environmental programs were evaluated on the basis of greenhouse gas emission reductions resulting from truck idling time reductions. The overall work was grouped into the four tasks:

- Task 1: Overview of Port and Terminal Technologies for Operation Systems and Existing Environmental Programs;

- Task 2: Technical Evaluation of Technologies and Operating Systems Incorporating Gate Reservation/Appointment for truck drivers;
- Task 3: Development of a Canadian Strategy;
- Task 4: Conclusion and Recommendations

3.1 Overview of Port and Terminal Technologies for Operation Systems and Existing Environmental Programs

Task one includes an overview of port information systems and terminal operating system technologies utilized by container terminals for processing container truck movements, and to reduce truck idling at terminal gates and in the yard. This task also looks at existing environmental programs implemented to reduce ports emissions specifically emissions associated with trucks engaged in container drayage. The review also included a literature review, a telephone surveys and site visits to port authorities and terminal operators.

Literature Review

The study examined existing terminal operation systems that incorporate gate reservation/trucker appointment technologies and environmental programs. The emphasis is on state-of-the-art port and terminal operation technologies; more specifically on freight information systems, terminal appointment systems and gate technologies that improve cargo velocity at ports and terminals.

The review was conducted primarily through the Internet and virtual library data scanning tools were used to obtain the information needed. Published documents were also consulted.

Telephone Interview

A telephone survey was conducted on a number of selected North American ports and terminals throughout identified in the literature review. Ports and terminals were selected for their size, implemented technologies and environmental programs. Emphasis was placed on ports/ terminals on the West Coast West due to their leading role with regards to environmental regulations and air emission reduction strategies over the last three decades. As such, in the Los Angeles/Long Beach Area the South Coast Air Quality Management District reported a near 65% reduction in GHG emission in 2003; these reductions are directly linked to the implementation of truck appointment systems in the LA/LB Port Authority district's and streamlining of operations.

West Coast Terminal/Port Visits and Reviews of Experience and Know-How

The telephone survey led to a selection of five ports (in addition to the Port of Montreal): Los Angeles, Long Beach, Oakland, Seattle and Vancouver; where terminal management programs were identified to be worthy of a visit. Lack of time prevented us from visiting the Port of Tacoma. In addition, several ports and terminals located on the East coast were contacted for information and site visits among them the port of New York/New Jersey (PANY/NJ). The ports of PANY/NJ declined our request for a visit.

3.2 Technical Evaluation of Technologies and Terminal Operating Systems

Task two examined existing and implemented technologies and Terminal Operating Systems (TOS) that have already incorporated gate reservation/truck appointment. It incorporated the following steps:

Evaluation of Existing Technologies and Terminal Operating Systems (TOS)

Review and evaluate information on existing port automation technologies and TOS obtained from the visited ports.. The analysis highlighted that the main drivers and institutional factors which had originally prompted the implementation of these technologies at North American ports and terminals.

Identification of Opportunities for Increased Operational Efficiency and Further GHG Emission Reductions

Identify features that could improve operational efficiency and GHG emission reductions. The Study looked at TOS applications to improve cargo velocity at ports and terminals and GHG emission reduction practices.

Evaluation of Greenhouse Gases Reductions

The evaluation of TOS efficiencies focused on the reduction of greenhouse gases produced by container trucks on port grounds. The study characterises the trucking fleet, the truck idle time, truckloads, etc. Once defined, the fleet was evaluated on fuel economy, full cycle emission sources (i.e. wheel to wheel, loads, etc.) and GHG emissions. Comparisons between baseline and future/predicted GHG emissions were also carried out.

3.3 Development of a Canadian Strategy for Reduction of GHG Emissions

In Task three a Canadian strategy was developed and applied to a terminal in the Port of Montreal. The strategy includes the following:

- Productivity and efficiency improvement at ports and terminals;
- Reduction of GHG emission associated with drayage activities;
- Evaluation of similar approaches;
- Canadian applicability;
- Conclusion and recommendations.

The emphasis is on developing a uniform approach for implementing a terminal information system across Canadian ports. Such a system would consist of various terminal appointment systems, TOS applications or other selected strategies, all aiming to increase cargo velocity, improve productivity and reduce GHG emissions. The plan would takes into account that some factors causing time delays, e.g. rail grade crossings, cannot be solved by application of this strategy.

3.4 Conclusion and Recommendations

Task four presents our conclusion and recommendations.

4 LITERATURE REVIEW

A literature review was carried out focusing on the twelve largest North American container ports listed in Table 4.1. The information was gathered primarily from the Internet using virtual library data scanning tools. These ports have the highest annual transiting container volumes (TEUs per year) and are in the process of implementing automated technologies, port community information and terminal operation systems, as well as environmental programs. The review indicated that the majority of container terminals employ the following:

- Terminal operating systems and automated technologies for managing truck and container movements at terminals, which integrate gate, yard and quay operations. The primary objective is to reduce truck idling times and increase truck turnaround times;
- Environmental programs that have been implemented to reduce port emissions with a prime focus on container truck emissions.

Table 4-1: North American Ports with Busiest Container Activities

Port Authorities	Containerised Cargo Terminal	Volume (TEUs) in 2003	Existing Terminal Operations Systems(TOS)	Description
Port of Los Angeles	Y	7 178 940	Y	GT Nexus, eModal, shipment link
Port of Long Beach	Y	4 658 124	Y	eModal, Automated Manifest System (AMS), ESC Embarcadero
The Port Authority of New York and New Jersey	Y	2 382 639	Y	eModal, SEALINK, FIRST
Port of Oakland	Y	1 923 104	Y	eModal, ESC Embarcadero
Port of Tacoma	Y	1 738 068	Y	eModal, shipment link
Vancouver Port Authority	Y	1 539 058	Y	EModal, Pacific Gateway Portal, Container Terminal Scheduling System
Port of Seattle	Y	1 486 465	Y	EModal, ESC Embarcadero
Port of Houston Authority	Y	1 437 585	Y	NAVIS
Montreal Port Authority	Y	1 108 837	Y	NAVIS
Port of Miami	Y	1 041 483	Y	eModal
Jacksonville Port Authority	Y	692 422	Y	eModal
Halifax Port Authority	Y	541 651	Y	COSMOS

The following findings are based on review of technologies and operation systems, covering gate reservations/appointments for truck carriers and environmental aspects of the marine sector.

4.1 Technologies and Terminal Operation System (TOS)

The terminals employ the technologies and operation systems to manage the activities associated with the transport of containers. The following sections brief description of the technologies and management systems employed by container terminals. It was noted that not only the reservation/appointment systems have an important effect of improving cargo velocity at ports and terminals, but also technology and other automation systems.

4.1.1 Sector Activities

For ease of comprehension the terminals are broken down into sectors each conducting specific activities. Since the container terminals are the chief users of these the technologies and systems, a description of the three most important activity sectors that take place in container terminals is presented.

Gate Sector

The Gate Sector (see Figure 4-1) is the entrance point for the container trucks and represents the first contact point (Portal and Pedestal Gates) between truck drivers and terminal authorities (gate clerks). Appointment systems and gate technology can reduce waiting time for trucks queuing up at the terminal.

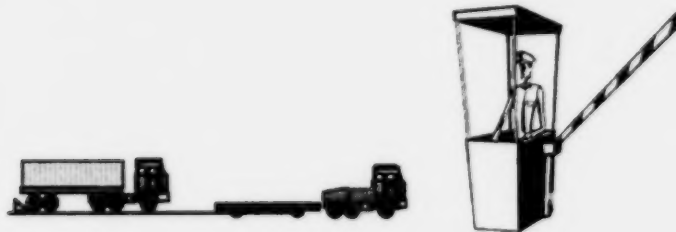


Figure 4-1: Typical Gate Sector

Operations included in this sector are container availability (loaded or empty) and storage location, trucker appointments, equipment identification and security.



Yard Sector

The Yard Sector (see Figure 4-2) includes all ground (**stacking in the yard**) or rail activities, which take place inside the terminal as well as security. The yard sector includes the interfaces between the Gate and the Quay at which ships are berthed.



Figure 4-2: Typical Yard Sector

These activities include the loading and unloading of containers (full or empty) on terminal trucks (including wheeled container), trains, and stacking containers in the yard. Other activities include container tracking, dispatching and inventory.

Quay Sector

The Quay Sector (see Figure 4-3) represents the marine entrance and exit point of the container terminal.

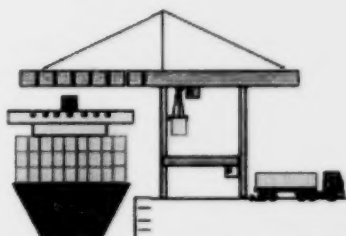


Figure 4-3: Typical Quay Sector

Its activity addresses all operations of loading and unloading containers (full or empty) on or off the vessel as well as container identification. The main cargo handling equipment for vessel loading and unloading is by:

4.1.2 Cargo Handling Equipment

Manufacturers are continually introducing new products that offer improved efficiency as well reduced emissions. Modern high capacity terminals employ autonomous guided vehicle system for transporting ISO cargo containers. The navigation system is based on millimetre-wave radar, providing position accuracy better than 3 cm. The ability to determine the location, orientation and motion of a vehicle or platform, is an essential competence of any autonomous vehicle.

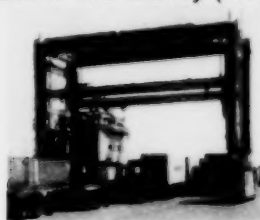
This section examines the various cargo handling equipment used in different sectors of the container terminal.

Common in-yard cargo handling equipment includes the following items:

Automated Stacking Crane:



Rubber Tire Gantry (RTG):



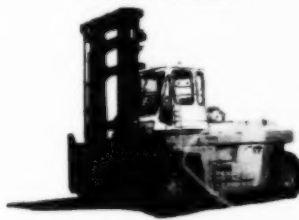
Straddle Carrier:



Reachstacker:



Forklift Truck:

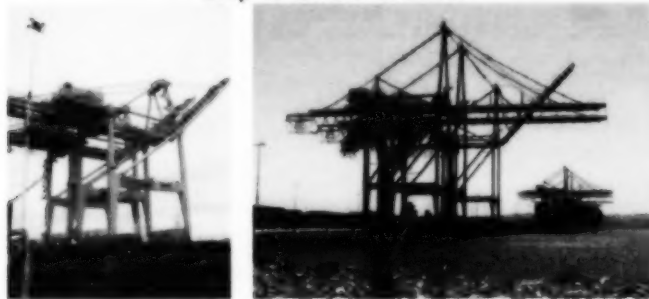


Top pick Handler:



Rubber Tired Gantry (RTG) cranes form the backbone of terminal cargo handling equipment. They are complemented by a range of more mobile stacking cranes. Rail Mounted gantry Cranes (RMGs) are more efficient and are used in terminals with on-dock rail facilities.

Ship-to-Shore Cranes:



Ship-to shore cranes are the primary means to unload container vessels. The productivity of these cranes is measured in lifts per hour. Dual hoist cranes can increase the number of lifts per hour by 20% whereas tandem cranes can handle the twice the number containers per hour.

4.1.3 Automation Technologies

The accelerated growth in container traffic forced terminals to employ technologies and management/operating systems that increase productivity (gate moves) and throughput by enhancing their capability to accurately track inventory, and relieve present and future bottlenecks.

New security initiatives and regulations also heavily rely on automated identification and tracking of containers as they enter and exit terminals and ports via ship, truck or rail. Manual identification and tracking processes are inherently inefficient and could represent a security threat.

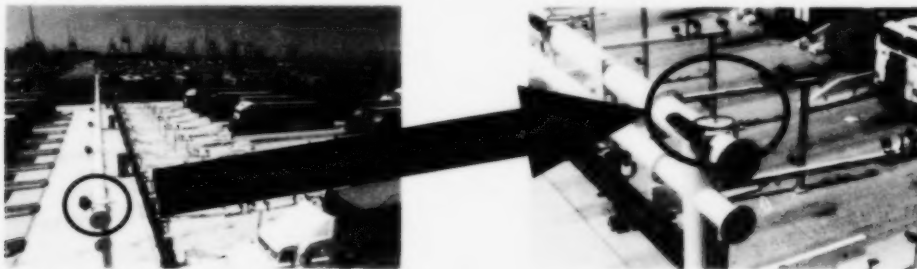
Table 4-2 to Table 4-9 present the different technologies implemented in container terminals, which satisfy the need for accurate real-time accounting of incoming, outgoing and existing inventory. It is important to note that these technologies are not "Stand alone". They are part of the overall Terminal Operation System (TOS) as a data recovery and/or data transmission tool.

It is also important to mention that not all container terminals use the systems and technologies described below. The reasons terminal operators have decided to implement systems and technologies will be discussed later.

Optical Character Recognition (OCR)

Table 4-2: OCR Applications

Description	Operation	Application
Optical Character Recognition	Equipment Identification and Security Enhancement	At portal and pedestal gates – automatically identify containers, truck plate and chassis number. Automated data capture at entry and exit gate to fully automate the gate process
		On quay crane, RTG and container handling equipment and rail portal gates – automatically identify containers
		On crane loading – automatically identify truck plate



Global Positioning System (GPS)

Table 4-3: GPS Applications

Description	Operation	Application
Global Positioning System	Equipment and Container Localisation	In yard on container handling equipment – help localise mobile equipment and container (for stacking and yard inventory)
		On quay crane, and rail portal – help localise mobile equipment and container (for stowing and stacking)

Radio Frequency Identification Device (RFID)

Table 4-4: RFID Applications

Description	Operation	Application
Radio Frequency Identification Device (Tags)	Equipment Identification, Localisation and Security Enhancement	On container – electronic transmission of transaction data prior to truck arrival (at gate)
		At portal and pedestal gates – automatically identify container and truck
		In yard – automatically identify and track handling equipment, container and truck

Electronic Seal

Table 4-5: Electronic Seal Applications

Description	Operation	Application
Radio Frequency Identification Device (Tags)	Container Localisation and Security Enhancement	On container – seal installed at origin and checked by reader at destination for any opening, closing or tampering with and can be monitored in real time, both in transit and in yard

Weigh-in-motion (WIM) Scale

Table 4-6: Weigh-In-Motion (WIM) Applications

Description	Operation	Application
Weigh-in-Motion Scale	Equipment Identification and Security Enhancement	At portal and pedestal gates – automatically weight, count and classify moving trucks (with or without chassis and containers) at specific location.

Closed-Circuit Television Camera

Table 4-7: CCTV Camera Applications

Description	Operation	Application
Closed-Circuit Television Camera	Equipment Identification and Security Enhancement	At portal and pedestal gates and in yard – monitoring traffic and terminal activities.



Variable Message Signs (VMS)

Table 4-8: Variable Message Sign (VMS) Applications

Description	Operation	Application
Variable Message Sign (VMS)	Traffic Control, Information (all types) and Security Enhancement	Before and at portal and pedestal gates – display real-time information (on traffic and terminal general situation)



Bar Code Readers and Mounted Data Collection Computer

Table 4-9: Bar Code Readers and Mounted Data Collection Computer Applications

Description	Operation	Application
Bar Code Readers and Mounted Data Collection Computer	Equipment Identification, Security Enhancement and Data Collection	At gate, in yard on container handling equipment, on quay crane, rail portal and or mobile – identify container (for stacking and yard inventory)



4.1.4 Port Community Information System

A Port Community Information System is a system structured to facilitate end-to-end electronic information flow between trading partners, optimise the terminal/trucking interface and provide the members with a web-based low cost connectivity option relative via EDI. In addition, such a system would enhance the visibility of cargo and port activity for shippers and members of the supply chain as well as enhance gateway

security, and reduce congestion and pollution. Currently centralised databases and technologies can offer the tools and information to the port community to improve inter-organisation information flow and hence service and business performance.

The following paragraphs summarise the existing web-based information systems and associates systems, as well as provide a reference and a brief description of each. The review identified Port Community Information Systems under consideration, in the stage of pilot project, or already implemented in some ports or terminals.

Port of Montreal Extranet

This public system was developed jointly by Transport Canada and the Port of Montreal to improve the efficiency and productivity of container movements through the port, by developing communications and information technologies applicable to container transport, in view of reducing communications costs and delays associated with gate congestion. The study recommended the implementation in the Port of Montreal of an extranet (defined as a virtual private network separated from the public Internet by a firewall) solution to address information exchange (Electronic Data Interchange – EDI) and gate congestion issues.

Benefits anticipated were:

- Less congestion at gates with fewer delays;
- Reduction of paperwork;
- Real-time container information;
- Improved operational efficiencies through better visibility of container status;
- Improved customer service; and
- Better planning and decision-making capabilities for all stakeholders.

The study was commissioned to prepare the design specifications for the extranet for the Port of Montreal community that would be used to develop and implement a full production system. It provides an outline of the extranet's infrastructure, functions, database, security and service level agreement. It recommended the implementation of a pilot phase be executed with a limited group of carefully selected participants to fine-tune the solution for more general use.

Freight Information Real-Time System for Transport (FIRST)

Supported by the Federal Highway Administration's Office of Freight Management and Operations, the Congestion Mitigation and Air Quality Improvement Program, and the I-95 Coalition, the FIRST Demonstration Project was funded and developed, in part, to provide unique solutions to freight transportation problems. FIRST is an Internet-based, real-time network that integrates many resources into a single, easy-to-use Web site on cargo and port information. Designed by the intermodal freight industry, in cooperation with public sector partners, FIRST uses the Internet as a platform to data in a variety of formats to facilitate the safe, efficient, secure, and seamless movement of freight through the Port of New York and New Jersey.

The FIRST Web site (www.firstnynj.com) provides real-time information on cargo status to ocean carriers, exporters, importers, foreign freight forwarders, customs brokers, terminal operators, and rail and trucking services. A trucking company, for example, can use the system to find out the status of a cargo container waiting to be picked up at the port. By verifying that the container is at the terminal and has been released for pickup, the trucker can avoid multiple telephone calls to the terminal and prevent unnecessary trips to the port.

When fully developed, FIRST will enable port users to post and receive information on the location and status of intermodal freight shipments, including export bookings, customs manifests, receipts and invoices, gate moves, carrier insurance/credit status, delivery confirmation, and truck identification. With connectivity to public and private ATIS systems, information on travel conditions along access roads and major freight routes serving the Port of New York and New Jersey will also be provided. Shared cargo and traffic information should facilitate the movement of cargo by reducing time delays caused by incomplete cargo documentation, delayed release of cargo, and bypassing traffic congestion. Eventually, FIRST will also include a truck driver's appointment system that would allow private terminals to provide appointment times for a trucking company to pick up or deliver its containers.

Several other key information and ITS systems have been or will be integrated with FIRST. SEA LINK®, which provides a central database of registered trucking companies and their truck drivers doing business at the port, has already been integrated with FIRST. Other systems expected to be integrated with FIRST include the U.S. Coast Guard Vessel Traffic Service and the U.S. Customs Automated Manifest System.

An analytical demand model was constructed to estimate the benefits of adding a terminal appointment system to the Freight Information Real-Time System for Transport (FIRST) project at the Howland Hook terminal in Staten Island, New York. The appointment feature was designed to save truck drivers time by allowing them to pre-register and reserve dedicated time-slots for expedited handling of cargo at terminal gates. The Howland Hook terminal provides an on-dock rail service and is connected to the North American intermodal rail network.

To investigate the potential time saving benefits of adding an appointment system, a simulation model was constructed using accepted transportation queuing theory concepts to determine queuing activity "with" and "without" the system in operation at various levels of acceptance (0-100%). Data input into the model was derived from field observations of queuing activity and terminal records collected over a period of five days in June 2002. Trial runs of the model "with" the appointment system included the following assumptions:

- The web based appointment system automatically tracked appointments;
- The number of vehicles entering the system was controlled by a preset capacity;
- Truck drivers were provided with an hour-long slot in which to show up at the terminal and receive expedited service;
- A dedicated lane was provided for appointment vehicles;
- No vehicles received a trouble-ticket for having improper information.

Trials run "without" the appointment system (0% acceptance) generated baseline data similar to that observed in the field. The model was calibrated to handle a weekly average of approximately 1400 vehicles per day. The author indicated the model would have to be recalibrated to represent conditions where baseline estimates were significantly different.

The "with" and "without" simulation trials were compared and the following results were reported. Overall, the results were highly dependent on the level of appointment system usage.

- At 100% use of the appointment system, the total in-terminal time across all vehicles was 40,539 minutes/day, a 48% decrease compared to the 0% use scenario;
- At this 100% use level, the evaluation team estimated a health cost savings of \$93,107/year (2003 dollars).

The evaluation team estimated annual environmental health impacts by combining time savings estimates, estimates of diesel emissions by the U.S. EPA, U.S. DOE, academia and private firms, and published estimates of health costs related to motor vehicle emissions.

The author noted the benefits observed are highly dependent on configuration of the baseline queuing system, and the level of system buy-in. At several levels of system buy-in investigated in the study, there was a significant increase in total time in-terminal by all trucks. For example with only 5% of trucks using the appointment system there was a 390% increase in the total time in-terminal. These increases in delay were due to the dedication of lanes to trucks with appointments, leaving insufficient capacity to accommodate trucks without appointments.

According to the FIRST Evaluation Final Report (U.S. Department of Transportation, 2003), the FIRST system did not gain measurable levels of use over the course of deployment. FIRST data users noted the major concerns with FIRST are that it has limited data and when the data is available, it is not always accurate and timely. As a result, this causes:

- Terminal operators have to answer additional inquiries via the Internet from trucking companies about data, which causes unnecessary work;
- Truck drivers have to visit multiple Websites to find all the information they need – which also causes additional effort that they are not likely to do on a regular basis.

Additionally, terminal operators and ocean carriers have begun to start their own Websites for their customers and are not going to send data to an outside source if they can do it in-house.

As a result of these low levels of usage and lacklustre customer acceptance, it was reasonably assumed that FIRST did not have any appreciable impacts on Port efficiency, congestion, or emissions during the evaluation period.

Pacific Gateway Portal (PGP)

PGP is a non-profit company operated by the Port of Vancouver. PGP is a web-based port community information system that serves stakeholders and customers in the Vancouver area. It provides for information on containers status, vessel activity, and real time video images from port landside infrastructure as well as driver validation (CAM). The primary interface for PGP is via the Internet.

The web portal also features a dangerous goods application and a truck appointment system available to registered users for a fee. The truck appointment/reservation system known as Container Terminal Scheduling System operational at all three terminals within the port has enjoyed considerable success. It was developed jointly by the VPA and TSI and designed to permit truckers to reserve time slots during gate hours. It has by and large gained acceptance by the trucking community by virtue of the ease of making reservations electronically through the terminals web page. Each is matched with transactions, which are determined by the terminal on the basis of yard and sector capacities. The terminal set aside dedicated lanes for trucks with appointments. All import container pick ups require reservations.

The truckers with reservations are given specified hourly time slots. All trucks must be in line at the gate entrance at least 15 minutes before the expiration of their slot reservation. Trucks arriving late are shunted to the non-reserved gates or require new reservations. Motor carriers who overbook or fail to honour rules are denied access to the reservations system. Motor carriers who persistently abuse the system risk having their licence to operate at the port revoked.

Benefits of the system to truckers are scheduled and seamless processing with minimum delays. Access can be readily achieved through a web-based interface. Although there are no costs for using the appointment system the, POV charges user fees for access to the web portal.

SynchroMet

SynchroMet™ On-Line, the virtual container yard service provider for the Oakland Port Community (Public System). The Port Authority and SynchroNet Marine Inc have partnered to implement a congestion management tool to alleviate public road and port congestion at local marine terminals. Transportation service providers and port users are able to integrate with SynchroMet to improve profitability and operating efficiency at the Port of Oakland.

Empty equipment (container) can be released through the virtual container yard (VCY) and matched in real-time with off-dock equipment needs to cover export bookings. SynchroMet reduces empty truck miles and waiting time at local marine terminals; having a positive impact economically and on the local environment.

SynchroMet provides Motor Carriers (trucks) and Ocean Carriers with the ability to:

- Communicate street inventory or equipment needs;
- Facilitate a street turn transaction with Ocean Carrier approval;

- Generate an EIR (Equipment Interchange Receipt) and transfer liability for the equipment;
- Access empty equipment direct from local ramps and depots (outside the terminal);
- Automate the confirmation process via EDI.

4.2 Proprietary Terminal Information Systems

SEA LINK® – Trucking Services

SEA LINK® provides for the thousands of trucking companies serving the Port of New York and New Jersey a central database of registered trucking companies and their truck drivers doing business. The trucking industries have convenient and immediate access to the region's extensive interstate highway system, to easily move cargo to inland destinations.

SEA LINK®, the Port Authority's uniform truck driver identification system, helps speed these trucks through their marine terminal gates, allowing their terminals to move thousands of containers each day to and from inland markets. With a single identification card for calls at any of the Port of NY and NJ's Marine Terminals, drivers save time, clearing gates quickly for dropping off and picking up cargo. SEA LINK uses ACES, the port's Automated Cargo Expediting System, to transmit information about the drivers to terminal operators.

eModal system

eModal is designed to improve efficiency and decrease congestion at container terminals. It provides a single point of contact for multiple container terminals and delivers valuable tools to the entire intermodal community. eModal offers detailed container status, vessel schedules, terminal locations, truck driver lists and more container, vessel and terminal information. These tools improve service to all parties in the transportation community. eModal gives one easy-to-use Web site for all container information needs.

eModal also provides extra benefits for trucking companies and terminal operators through a gate appointment system. Trucking companies use eModal to pre-approve their drivers for container pick up and drop off. eModal automatically sends this pre-approval information to the terminals. So, when truck drivers arrive at a terminal, they spend less time waiting at the gate. Terminals also rest assured knowing they are delivering containers to the trucking company's designated drivers. eModal's trucker status features reduce trucker turn times and improve security at the terminal.

Maritime Global Net

Maritime Global Net (MGN) offers access to products, services, news and other industry related data. MGN includes the details of over 80,000 maritime-related companies and contacts, from industry associations to world ports.

The MGN site provides Internet users with easy, unrestricted access to maritime information, products, and services. Maritime Global Net is owned and operated by Maritime Information Systems, Inc., a Rhode Island based company, which provides

consulting, contracting and hosting services to a variety of maritime and non-maritime companies.

4.3 Terminal Operating Systems (TOS)

Terminal Operating Systems (TOS) can be defined as an operating systems managing (by integrating technologies) the flow of containers through the terminal, ensuring containers are properly dispatched and movements are handled efficiently.

Unfortunately, few "off the shelf" computer programs available are designed for specific functions and do not cover the total requirements for a terminal operating system. To that end, most terminal operators decided to develop in-house" software, integrating existing technologies, "off the shelf" programs and in-house developed software to respond to the terminal operational needs.

The following sections describe "off the shelf" TOS such as Yard Managing Systems, Appointment/Reservation Systems and Security Systems available on the market.

NAVIS (Yard Management)

NAVIS is a system which automates and integrates data input functions, allowing terminal operators to see what is happening in real-time, including container movements from the gate to vessels or rail, in their container terminal.

NAVIS SPARCS, used by more than 175 terminals in 44 countries around the world, enables the operator to fully automate and optimise vessel and rail planning, yard allocation, and equipment dispatch, with minimal human interaction, which means faster, more efficient loading and discharge. Additionally, SPARCS TOS keeps pace with advances in equipment technology (OCR, RFID), allowing the terminal operators to maximise their investment in the latest equipment, such as twin lift straddle carriers. By helping optimise equipment, land and container moves, vessels spend less time at the quay, enabling a terminal to accept more requests from shippers and increase throughput.

Many terminals implement simple systems for servicing quay cranes resulting in the underutilisation of container handling equipment (CHE), leading to longer travel distances, un-laden travels and delays. Because SPARCS TOS operates in real-time, operators can track current CHE and productivity which means truck drivers won't have to wait for work instructions, assuring that drivers are making strategic moves, saving them time and allowing them to concentrate on driving, and not on the context of the move.

COSMOS (Yard Management, Gate Control and Container Tracking)

COSMOS System is a fully integrated yard control, terminal/vessel planning system supported in real time by RF, using handheld and VMTs in all terminal operations.

SPACE is COSMOS' yard planning software. Based on user-defined parameters, it automatically determines the optimal position for containers that enter the terminal until they are loaded on the right vessel, barge, truck or train. A location in the terminal will be automatically assigned to every container entering the terminal. The characteristics of

the container, such as the type of container, its destination, the date of departure, weight, etc., determine the selected area. Within the assigned area, containers will be stacked according to user-defined algorithms. The planner defines planning rules; based on these rules, the system then determines the optimal position for each container. The planner just handles the exceptions and fine-tunes his planning rules. SPACE can operate in any terminal environment, wheeled or grounded, and CHE employed, e.g., straddle carrier, reach stacker, RTG or RMG operated.

An important module of SPACE is TRAFIC. This module automatically generates and transmits instructions to terminal equipment drivers. As soon as these drivers have confirmed the execution of the move, SPACE is updated in real-time, guaranteeing the accuracy of the system.

COSMOS also provides Gate Control and Container Tracking functionalities. Every container entering the terminal is checked administratively and physically, after which the order is confirmed. Checkers use hand-held terminals linked to CTCS to update the database in real-time. After the container is checked, all other software programs linked to the central database are able to use the available container information, e.g. SPACE can start to position containers on the yard or SHIPS can plan the loading of a vessel. CTCS also monitors all operations. Whenever the information concerning a container is changed, e.g. a container is moved or a vessel arrives, CTCS is automatically informed and the database is kept up-to-date at all times.

Embarcadero (ESC) (Yard Management, Gate Control and Appointment System)

ESC's Web-based visibility tools (VoyagerTrack and webTAMS), employ Differential Global Positioning Systems (DGPS), and wireless local area networks (WLANS) to report on the exact position of equipment and provide real-time communication for the terminal community complement terminal operating system software. Outside the terminal, ESC also provides cargo visibility at any event using real-time Web access tools. With automated intermodal solutions from ESC, terminals improve yield management by increasing terminal and yard efficiency, reducing operational costs, improving throughput, and elevating levels customer service.

ESC's Premier Appointment System (PAS) is a real-time appointment module for motor a carrier that extends the functionality of VoyagerTrack®. The PAS module comes standard with VoyagerTrack. This capability in VoyagerTrack allows truck drivers to schedule arrival appointments at the gate resulting in reduced wait time for motor carriers.

ESC offers smartGATE™, providing centralised, remote processing of gate transactions for intermodal facilities. smartGATE includes hardware (Optical Character Recognition (OCR), RFID, GPS, Smart Camera Technologies) and software. A key module of smartGATE is Intelligent Camera, a Closed Circuit Television (CCTV) that provides accurate and real time images of the terminal.

VoyagerTrack and webTAMS-allow intermodal customers, motor carriers and other transportation community stakeholders access to secure real-time critical information and notifications. With VoyagerTrack and webTAMS, container transportation communities have the ability to check container availability, schedule appointments for pickup and delivery, and make on-line demurrage payments.

The CATOS application, a software product of ESC's partner Total Soft Bank, offers automated rail planning, yet provides a high level of flexibility for incorporating manual adjustments. The CATOS Rail Planning module manages container reservations, rail loading based on blocks and on-dock loading, all with the objective of building each train to maximum efficiency. Import and export rail loads are efficiently planned as to reduce the lifts required by an on-dock rail marine operation. Just as with CATOS yard and vessel applications, Rail Planning interacts with wireless RDTs (Radio Data Terminals). The application supports various types of container recognition for gate-in and reefer container control.

Maher Terminal Logistics Systems Gate and Yard Automated System

Massport launched a web-based Gate and Yard Automated System (GYAS) at Conley Terminal. This system, designed by Maher Terminal Logistics Systems, is the latest in a series of capital program improvements Massport has undertaken at Conley. Carriers and shippers now have access to real-time information about their container(s) movements through Conley. This software also gives Massport an automated approach to yard management, providing the most efficient and productive use of terminal staff and yard storage space.

This system is designed for use by carriers, truck drivers, brokers, and forwarders. Companies moving cargo through Conley Terminal have been assigned passwords with varying degrees of access to the system. Each company's access is determined by the level of control they have in the transportation of cargo through Conley Terminal, and is limited to their cargo and equipment. The GYAS software uses an internet browser-style interface to provide the intuitive tools to enter bookings and manifests, as well as locate important information concerning bookings, containers, manifests, and trucker contracts. A variety of reports and routines are also available.

In addition, any New England shipper or consignee moving container(s) through Conley Terminal has an opportunity to obtain information about their container(s). Access is available via the Internet or by phone.

4.4 Terminal Container Positioning and Inspection Systems

WhereNet

The WhereNet system provides a single, integrated wireless infrastructure for real-time location, messaging, and telemetry applications. Driven by wireless radio WhereTags and WhereLAN locating access points, WhereNet offers both a real-time locating system (RTLS) and an access point for non-WhereNet wireless LAN clients and applications. The WhereNet system consists of four major components:

The WhereLAN Location Sensor (LOS) and Locating Access Point (LAP) are the core components of WhereNet's Real Time Locating System (RTLS).

The WhereTag III is the first level component of the WhereNet Real Time Locating System (RTLS). It is a low-cost wireless device that attaches to a resource (such as an asset, pallet, container, vehicle, etc.) and periodically broadcasts, via radio, its unique identification number. WhereNet's RTLS infrastructure detects that signal and precisely locates the tag and its associated resource.

The WhereNet WhereCall II is a key component of the WhereNet Wireless Parts Replenishment System, which provides a highly flexible wireless solution that eliminates the need for wired line-side infrastructure and can replace paper based Kanban Systems.

Each container of parts is associated with a wireless WhereCall, which transmits its unique identification when the call button is pressed by the operator. This transmission is received by a network of WhereNet antennas that are strategically installed at ceiling height within a customer manufacturing area.

WherePort II is a proximity communication device that is used to trigger a WhereTag II to transmit an alternate "blink" pattern. When a WhereTag II passes through the WherePort's field, the tag can initiate a pre-programmed and (typically) faster blink rate to allow more location points as a tagged asset passes through a critical threshold, such as a shipping/receiving dock door or from one zone to another. When the WhereTag II is sending WherePort-initiated blinks, the tag includes the identification number of the WherePort II. More than 32,000 unique identification numbers are available.

SAIC – Integrated Container Inspection System (ICIS)

ICIS offers an integrated-system solution to the shipping industry's challenge of enhancing container security without impeding traffic. When equipped with SAIC's high-speed radiographic imaging, radiation scanning and Optical Character Recognition (OCR) capabilities, ICIS can scan high volumes of containers in the normal flow of traffic at the gates or on the quay. Just as important, ICIS can integrate data from these and many other sources, including terminal security, automation and management systems, for use in security and productivity applications.

4.5 Environment

For port operations, environmental management is often primarily oriented towards water, soil quality, sediment quality and waterfowl due to concerns on spills, contamination from underground storage tanks and water discharge systems. Regarding air quality, it is most often through economic incentives that environmental performances are achieved. As such, ports and terminals manage to achieve optimal loading and unloading efficiencies of ships and trucks. Investment in technologies targeting the reduction of emissions will often only occur if initiated for economic reasons.

Policies or regulations are therefore often required to provide the catalysts for significant emission reductions.

4.5.1 Legislation and Other Programs

Several regions face rising ambient air contaminant levels due to increases in traffic congestion and exponential growth of international trade. To address these issues, regulations and other incentive programs exist throughout North America to mitigate air emissions in port areas. Incentives such as the Lowenthal Bill in California have been implemented to mitigate air emissions, particularly from heavy-duty truck idling. Table 4-10 gives a list of the anti-idling regulations in North America (including Montreal).

This table presents a brief summary of idling and smoke emission requirements set in place by states, provinces and municipalities as enforcements to reduce emissions from idling activities. Idling issues can also be addressed under vehicle noise regulation, which virtually every state and municipality regulates. This information was taken from a Fleet Owner Newsletter dated from Sept. 16, 2003.

Table 4-10: State and Municipal Idling Regulations

Alabama	Prohibits the emission of "visible air contaminants from diesel-powered motor vehicles or other movable sources" of a shade or density greater than 20% opacity for longer than five consecutive seconds.
Arizona	Regulates smoke emissions and limits idling to five minutes state-wide. There are exemptions for traffic conditions, onboard equipment like reefer units and for heat/cooling for drivers sleeping in parked vehicles.
California	Regulates smoke emissions state-wide. Idling is limited to 30 minutes at marine ports and terminals processing 100 000 or more containers per year. Certain municipalities also limit idling. The California Air Resources Board also has a state-wide ban on idling of diesel trucks. Beginning with model year 2007, idling would be limited to five minutes and vehicles would be required to have a tamper-proof engine idle shutdown device or Alternative Power Unit (APU).
Colorado	Regulates smoke emissions state-wide. Idling restrictions are also in place within Denver, Aspen and Colorado Springs. There are certain exemptions for low ambient temperatures, emergencies, etc., but not for sleeping in the vehicle.
Connecticut	Limits idling to three consecutive minutes. Certain exemptions made for traffic congestion, breakdowns, engine heating at temperatures below 0oC and the operation of heating, cooling or auxiliary equipment if necessary to accomplish the intended use of the vehicle. Air Management personnel enforce the regulations.
District of Columbia	Limits truck idling to three minutes, unless vehicle is powering with Power Take-Off (PTO) ^a equipment or ambient temperature is below 0oC. Enforcement is handled by Air Quality Division field officers, metropolitan police, and parking enforcement personnel. Fines are US\$500 for a first offence, US\$1000 for a second, US\$2000 for the third and US\$4000 for a fourth offence. Other penalties may also apply.
Georgia	Idling restrictions are in place for Atlanta.
Hawaii	Idling is prohibited state-wide, including for powering A/C. There are some very limited exemptions. The Department of Health enforces the regulations. Fines can reach US\$25,000 per day for each offence.
Illinois	Idling is prohibited on business streets state-wide for longer periods than are necessary to load/unload.
Maryland	Idling is generally limited state-wide to five minutes, with some specific exemptions. The State Highway Patrol enforces idling regulations.
Massachusetts	Idling is limited state-wide to five minutes with certain exceptions. Regulations may be enforced by police, fire, board of health or building inspection personnel. The City of Boston actively enforces anti-idling restrictions with a dedicated anti-pollution enforcement team.
Minnesota	The City of Owatonna limits idling on residential streets.
Missouri	The City of St. Louis limits truck idling to ten minutes. There is a fine of up to US\$500 for violations and the possibility of up to 90 days imprisonment.
Montana	During periods of poor air quality (as declared by the health dept.) Lewis and Clark County limits idling to two hours in any 12-hour period. The City of Helena limits idling to two hours.
Montreal	Montreal is currently reviewing a project of idling nuisance regulation in the city. The project would limit idling to three minutes for any type of vehicles at the exception of heavy duty diesel vehicles which would be limited to five minutes idling (Ville de Montréal, 2005).
Nevada	Regulates smoke emissions state-wide and limits idling state-wide to 15 minutes except for emergency vehicles, vehicles in traffic congestion, while vehicles are being repaired, for operation of certain specified equipment or when emissions are treated and/or contained by an approved means. Fines are US\$100 to US\$500 for a

	first offence, US\$500-US\$1000 for a second, US\$1,000-US\$1,500 for the third and US\$1,500-US\$2,500 for a fourth offence.
New Hampshire	Limits idling state-wide to five minutes if the ambient temperature is above 0oC. Limits are extended to 15 minutes when the ambient temperature is between -23oC and 0oC. Unlimited idling is permitted if the temperature is below -23oC "where no nuisance is created."
New Jersey	Limits idling of diesel or gasoline-powered trucks state-wide to three minutes unless the vehicle is at the operator's place of business, then the limit is 30 minutes. If a vehicle has been stopped for three or more consecutive hours, idling is limited to 15 consecutive minutes. There are specific exemptions, including for operating refrigerator units and PTOs and for truck sleepers in non-residential areas if the driver is sleeping or resting.
New Mexico	Regulates smoke emissions state-wide, specifically including emissions during idling. Smoke opacity is limited to 30% for no more than ten seconds at altitudes of less than 2440 m (8,000 ft) or 40% when vehicle is being started.
New York	Limits diesel truck idling state-wide to five minutes with exemptions for powering certain auxiliary equipment such as PTOs or cranes or if a truck is motionless for more than two hours and the ambient temperature is below -4oC. Within New York City, idling is limited to three minutes. Anti-idling laws are enforced, generally by the State Highway Patrol.
Pennsylvania	Limits diesel truck idling within the City of Philadelphia to two minutes. Trucks may idle for up to five minutes when the ambient temperature is below 0oC. and for up to 20 minutes when the temperature is less than -7oC. Enforcement is by Air Management Services or police department personnel. Fines are US\$300 per day, per violation with court appearances possible for repeat offenders.
Rhode Island	Regulates smoke emissions state-wide
Texas	Has local idling limits for diesel trucks in several cities, including Houston and Dallas. In eight counties in the Houston-Galveston area idling is also prohibited for more than five minutes during the months of April through October. There are some exemptions. Fines range from US\$500-US\$1,000.
Utah	Regulates smoke emissions state-wide and limits continuous idling to 15 minutes in Salt Lake, Davis and Utah Counties in the Salt Lake City area. Davis and Utah Counties permit up to 45 minutes of idling in a 120-minute period. There are certain exemptions, including for emergency vehicles, to supply power to refrigeration units and to supply heat/AC to sleeper cabs. In Salt Lake County, environmental, health, police or Highway Patrol officers may issue citations. Fines typically begin at US\$500 and are determined by the nature of the violation.
Virginia	Limits idling to three minutes in commercial and residential areas unless it is to provide power for devices other than for heating or cooling the driver. Diesel trucks may idle up to ten minutes to minimise restart problems. The Department of Environmental Quality enforces idling regulations.
Washington	Regulates smoke emissions state-wide.
British Columbia	Regulates smoke emissions province-wide.
Ontario	Regulates smoke emissions province-wide.

- a Power take-off equipment. Any equipment mounted on a truck and operates off the mechanical power of the engine. Would not include hydraulic equipment powered by electricity.

Lowenthal Bill

The Assembly AB 2650 Lowenthal Bill was implemented on January 1st, 2003 (Lowenthal S., 2002) to limit truck idling at marine terminals in the South Coast Air Quality Management District (SCAQMD) and the Bay Area Air Quality Management District (BAAQMD). A US \$250 fine is affected to a terminal for each trucker who had to wait at a terminal gate for more than 30 minutes. This encourages and justifies the use of appointment systems and/or to open the terminal gates over longer hours.

Since 2003, when the Lowenthal Bill came into effect, significant environmental benefits have been achieved. The following emissions in Table 4-11 were calculated by CARB (using the EPA MOBILE6 model) for truck idling emissions.

Table 4-11: Emission Calculations for Truck Idling Before and After the Lowenthal Bill (2003)

NO_x emissions were reduced by 61.5% in 2003	
Pre 2003 :	1300 ton/yr
2003 :	500 ton/yr
PM emissions were reduced by 63.5% in 2003	
Pre 2003 :	55 ton/yr
2003 :	20 ton/yr
CO emissions were reduced by 64% in 2003	
Pre 2003 :	1530 ton/yr
2003 :	550 ton/yr

Following the implementation of the Bill, some consideration was given for carriers not using the appointment system. Therefore, the Bill was amended (AB 1971) in February 2005 (Lowenthal S., 2005) to prompt trucks not to exceed the turnaround time of 60 minutes while conducting business at the marine terminal and obliges all motor carriers to use an appointment system. The Lowenthal Bill also requires that ships at berth switch to lower emission generators by connecting to port electrical power systems. The Bill applies to all terminals located in California: Los Angeles, Long Beach and Oakland terminals.

In addition to the Lowenthal Bill, since February 1st, 2005 a California state-wide regulation limits diesel-fuel commercial motor vehicle idling to five minutes at any location. This also applies to diesel-fuel auxiliary power system (APS) used to power heaters, air conditioners, or any ancillary equipment on vehicles if equipped of a sleeper berth and if the vehicle is located within 100 feet of a restricted area (homes and schools).

Act on Port Air Quality Program

In Texas, similar incentives as the Lowenthal Bill in California exist. On September 1st, 2003 the Act on Port Air Quality Program impeded diesel engines to idle or queue for more than 30 minutes while waiting to enter a port or navigation district.

Texas Emission Reduction Program (TERP)

The 77th Texas Legislature enacted in 2001, Senate Bill 5 to include an air emission reduction incentive program called the Texas Emission Reduction Plan (TERP). This program provides incentives – primarily by granting funds – to improve air quality in Texas. The program is voluntary and aims at reducing NOX and VOC emissions.

Canada's Commercial Transportation Energy Efficiency and Fuels Initiative

Improving energy efficiency is among the initiatives of Canada's Climate Change Plan under which was elaborated the Commercial Transportation Energy Efficiency and Fuels Initiative. This initiative includes a rebate for devices to reduce engine idling in the on-road commercial transportation sector. Such devices provide truck-cab or bus-interior

heating and/or cooling, inhibiting the need to run the engine for the functioning of these appliances. The rebate is eligible to Class 6, 7 or 8 diesel-powered trucks and buses that are registered and licensed for on-road commercial service in Canada.

Natural Resources Canada's Office of Energy Efficiency (OEE)

Also, as part of the programs offered to improve energy efficiency in every sector of the Canadian economy, the Natural Resources Canada's Office of Energy Efficiency (OEE) runs the "Idle-Free Quiet Zone" campaign. This campaign was conceived to raise awareness in the trucking sector on harmful effects of unnecessary engine idling such as the impacts on the enormous amount of fuel and money wastes, the generation of greenhouse gas emissions and the impacts on human health. The campaign ran at first for two weeks before being implemented in specific cities. It has since broadened throughout the country. Today, the anti-idling campaign is gaining prominence and the logo in Table 4-4 is starting to be seen more and more often.



Figure 4-4: Logo of the Anti-Idling Campaign

Heavy-Duty Diesel Engine Standards

The federal government of Canada imposes emission standards for new vehicles. Unfortunately, once in-use, the engines can generate higher emissions without any legislation. This is why provinces are starting to put in place some vehicle inspection programs to ensure compliance.

In California, since 2004, heavy-duty diesel engine standards limit NOX emissions from these engines by 50% from the 1998 levels (CARB, 1998a). Starting in 2007, the CARB adopted after-treatment forcing emissions standards will cut both NOX and PM emissions from new engines by another 90% (CARB, 2001a). For older vehicles, California also has a couple of heavy-duty vehicle inspection programs aiming at reducing emissions from the existing fleet.

Heavy-Duty Vehicle Inspection Programs

There are more and more heavy-duty vehicle inspection programs set in place throughout North American jurisdictions. Most programs implement a state or province-wide highway network control that involves inspectors patrolling highways and regulating truck exhausts based on the visible opacity of smoke. The programs in North America include (but are not limited to):

- State of New York: Statewide highway network control and annual inspection in the city of New York;

- State of New Hampshire: Statewide highway network control;
- State of Massachusetts: bi-annual inspection;
- State of Maine: Statewide highway network control;
- British-Columbia: Statewide highway network control;
- Ontario: annual inspection for vehicle of 3-years and more of age, and restricted highway network control;
- Quebec: recently accepted (July 2005) PIEVAL (*programme d'inspection et d'entretien des véhicules automobiles lourds du Ministère du développement durable, de l'environnement et des parcs du Québec*) program with implementation planned for July 2006. The program establishes a province-wide highway network control. (The acceptance of the program has appeared in the Gazette of Canada during fall 2005).

In addition, California has two truck inspection programs: the Heavy-Duty Vehicle Inspection Program (HDVIP) and the Periodic Smoke Inspection Program (PSIP). Under the HDVIP, carriers and buses are tested for excessive smoke emissions and inspected for tampering at random roadside locations, weigh stations and fleet facilities. The PSIP compliments the HDVIP by requiring California-based truck and bus fleets with two or more diesel vehicles to annually test their own vehicles to measure smoke opacity and to check for tampering.

Diesel Sulphur Content

New regulations to reduce sulphur in fuel have been implemented by both Environment Canada and EPA. The two jurisdictions have set the same levels and same implementation timing. The regulations on diesel fuel include the following new and upcoming regulations:

- 15 ppm for on-road diesel (sold) by Sept. 2006;
- 15 ppm for off-road diesel vehicles by 2010 by 2012 for the rail and marine sector.

Off-road diesel standards will apply to diesel fuel mainly used by harbour vessels and ferries. Marine fuel oil used by larger ocean-going vessels is not addressed by these regulations. However, Canada and EPA plan to address marine fuel oil through MARPOL (discussed in the following paragraphs).

Other potential policies target fuel requirements. These requirements would be addressed by the Canada Shipping Act for fuel use and CEPA 1999 for import/production/sale of fuel.

International Maritime Organisation (IMO)

The International Maritime Organisation is responsible for several important international conventions, one of which is the resolution A 963(23) *IMO Policies and practices related to the reduction of greenhouse gas emissions from ships* adopted in November 2003 (IMO). As part of this resolution, the Marine Environment Protection Committee (MEPC) made progress on developing draft Guidelines on the CO₂ Indexing Scheme and urged members to carry out trials using the scheme and to report to the next session. One

purpose of developing guidelines on CO₂ emissions indexing was to develop a simple system that could be used voluntarily by ship operators during a trial period. The IMO guidelines on greenhouse gas emissions address all six greenhouse gases covered by the Kyoto Protocol (Carbon dioxide; Methane; Nitrous oxide; Hydrofluorocarbons; Perfluorocarbons; and Sulphur hexafluoride).

The IMO also recognised the magnitude of vessels emissions. As such, it adopted the International Convention for the Prevention of Pollution from Ships (1973 and modified by the Protocol of 1978, often referred to as MARPOL 73/78). Annex VI to this convention was developed to reduce air pollution from ships (SO_x, NO_x, CFCs and HCFC emissions). Ratification of Annex VI was achieved on May 19, 2004 and came into force a year later, on May 19, 2005. Annex VI requires ships of a specified size and that are flagged in countries that are signatories to the agreement to comply with specified emission requirements. Also, ships entering a port of a country that is a party to Annex VI must comply with the emission requirements of Annex VI irrespective to whether or not the vessel's flag state is a party to Annex VI. The agreement applies to vessels of 363 gross registered tonnes (400 tons) and above, as well as fixed and floating drilling rigs, and other platforms and to fuels used for propulsion and auxiliary equipment.

Sulphur Emission Control Association

Canada and the United-States are presently not parties of the Annex VI of the MARPOL 73/78 Convention. Canada has a target date of November 2006 to complete changes to domestic legislation required to accede to Annex VI and become a party to the agreement. Similar work is underway in the United States. To and while achieving this, Environment Canada has implemented with Washington State a strategy to reduce emissions through the Georgia Basin International Airshed Steering Committee called the Sulphur Emission Control Association (SECA). SECA has now geographically and extended their action area to include the East part of the continent, now reaching the Great Lakes area. Inherent to the name, this program is most influenced by reductions in SOX emissions. Reductions in other pollutants such as oxides of nitrogen, particulate matter and carbon dioxide emissions unfortunately do not carry as much weight.

Use of Canadian Fuel

Through SECA, one of the programs is to encourage ship owners to use Canadian Fuel. The fuel sold in Canada has a sulphur content of 1.8 – 2.0% against the IMO standard of 4.5%. The use of Canadian fuel reduces significantly local pollution from SO₂ emissions reductions. Governments will be encouraged by SECA to create incentives for ship owners to buy fuel in BC and use it. This program is planned to be implemented by 2007.

GVRD Regional Air Quality Management Program

In British Columbia, the Greater Vancouver Regional District (GVRD) is mandated to look up on the regional air quality under the provincial Waste Management Act. The Vancouver Port Authority must therefore respond to the GVRD on their emissions, especially since recent forecasts made for the GVRD (Levelton 2003a; Levelton 2003b) anticipate significant increases in:

- Smog-forming emissions such as marine diesel particulate emissions (over the next twenty years);
- Regional air quality impacts due to emissions from docked vessels and port activities such as cargo handling and land/rail based transshipment of goods.

4.5.2 Overview of Canadian Initiatives in the Marine Sector

In Canada, two federal regulatory authorities can regulate emissions from the marine and transportation sector: Transport Canada and Environment Canada (see Table 4-12).

Table 4-12: The Two Canadian Regulatory Authorities of the Marine and Transportation Sectors' Emissions

Transport Canada:	- Regulates marine propulsion engine emissions for engines > 37 kW - In-use fuel standards
Environment Canada:	- Regulates emissions from marine diesel engines < 37 kW - Quality of fuel produced, imported and sold in Canada

Summary of the initiatives taken which target the marine sector include:

- 2005 emission inventory methodology development;
- Evaluation of technology/fuel options;
- Evaluation of policy/management options;
- Investigate diesel retrofit program options;
- International and domestic marine traffic study;
- Continuous Water Injection demonstration projects;
- IMO-MEPC, including participation in the Prevention of air pollution from ships Working Group;
- Participation in Marine Vessel Air Quality Work Group;
- Participation in "post-Seattle consortium" as it develops (US and Canadian West Coast ports, air quality agencies, other marine stakeholders);
- Participation in "West Coast Clean Diesel Collaborative" as it develops (US and Canadian West Coast agencies and other stakeholders);
- Development of Georgia Basin/Puget Sound International Airshed Strategy (marine vessel emissions are an important component);
- Others.

4.5.3 Truck Idling Behaviour and Influences on Emissions

Trucks operate a significant amount of the time at idle; one reason of idling being delays from port terminal operations. Truck drivers often operate their engines at idle to provide cab climate control, to power on-board appliances and/or to keep the engine oil warm to avoid cold-start problems during winter months. In fact, according to a pilot survey on truck idling trends conducted in Northern California, the majority of drivers run their engines at idle mainly for heating (67%) and air conditioning (83%) purposes (Brodrick et al., 2001). These survey results suggest that if heating and air conditioning could be

maintained using an alternative idle reduction strategy, truck idling emissions could significantly be reduced.

It should also be noted that during idle operation, drivers sometimes operate their engines at elevated engine speeds to provide more power to:

- Operate climate control devices and on-board accessories;
- Reduce cab noise and vibration;
- Reduce engine wear associated with low speed idling.

This results in a significant increase in fuel consumption and therefore CO₂ emissions. The CARB proposed to install on new 2007 and subsequent diesel models an idle shutdown system which could be designed to shut down the engine after 5, 10 or 15 minutes depending on the settings in place (i.e. transmission in the "neutral" or "park" position, parking brake engaged, etc.).

Other options include installing alternative idle reduction devices. These devices would provide power for cab heating and cooling, engine heating, and electrical power to charge batteries and operate on-board accessories. Current commercially available idle reduction devices capable of providing some or all of these necessities include:

- Automatic stop-start systems (come in two options):
 - An "engine only" option, which monitors the battery charge level and the engine oil temperature; and,
 - A "cab comfort" option which includes monitoring of "engine only" parameters as well as sleeper berth temperature;
- Auxiliary Power Unit (APU): generally comes out to be internal combustion engines which must comply with the applicable emission standards and test procedures for their fuel type and horsepower category;
- Power inverter/chargers for use with batteries and/or grid supplied electricity.

4.5.4 Vehicle Emissions Calculation Models

Several recent studies were analysed to identify the methodologies used for estimated emissions from truck idling. Such models include:

- Micro-Fac;
- GHGenius;
- OFFROAD;
- EMFAC;
- MOBILE;
- MOVES.

The Micro-Fac (Singh R. B., Sloan J.J., 2005) is a micro scale emission factor model that uses the same input data as Mobile (see hereunder) for the emissions, but handles them differently to generate emission factors to suit for air quality impact assessments of

roads. The model calculates CO, NO_x, PM₁₀ and PM_{2.5} emissions. It also has an integrated fuel consumption model used to calculate CO₂ emission factors assuming that the carbon content of the fuel is fully oxidised into CO₂.

The GHGenius model ((S&T)2 Consultants) developed for Canadian light and heavy trucks can determine the full fuel life of GHG emissions. The model has been developed for Natural Resources Canada over the past five years. It is based on the 1998 version of Dr. Mark Delucchi's Lifecycle Emissions Model (LEM). GHGenius is capable of analysing the emissions of many contaminants associated with the production and use of traditional and alternative transportation fuels. Since GHGenius targets the lifecycle emissions, it is based on overall fuel usage and cannot isolate specific idling emissions.

The OFFROAD model (Starcrest Consulting Group, LLC, 2004b) was developed to estimate emissions from off-road equipment fleets in the State of California. The model includes industrial equipment such as CHE. This model was used to estimate emissions for the port of Long Beach 2002 emissions inventory. However, the California Air Resources Board (CARB) has not developed a publicly available version of the OFFROAD model. Therefore, for the POLB study, the agency ran the model using the data collected from terminal operators and increased by data provided to ARB through the Wilmington Air Quality Study.

EMFAC (short for Emission FACTor) (California Air Resources Board, 2002) is a Fortran computer model developed by the California Air Resources Board which is capable of estimating emission factors for vehicles fuelled by gasoline, diesel or electricity. Both inventories mentioned above used this model to calculate emissions from truck idling. The model has the ability to generate emission factors specifically for idling vehicles. However, it was designed for vehicles operating in the State of California. This presents a limitation regarding the effort and testing that would be required to adapt the model to suit analysis of Canadian vehicles and locations.

MOBILE is a vehicle emission factor model developed by the U.S. EPA (US EPA, 2002) to provide emission estimates of vehicles powered by gasoline, diesel, electricity or natural gas. It calculates average in-use fleet emission factors for hydrocarbon (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), exhaust particulate matter (which consists of several components), tire wear particulate matter, brake wear particulate matter, sulphur dioxide (SO₂), ammonia (NH₃), six hazardous air pollutants (HAP), and carbon dioxide (CO₂). For greenhouse gases, the model generates emission factors for carbon dioxide, methane and nitrous oxides. The conversion to carbon dioxide equivalent (eCO₂) is done subsequently using global warming potentials of 21 and 310 as the multipliers for methane and nitrous oxide, respectively.

In Canada, Environment Canada has modified MOBILE6 by creating the MOBILE6C version (latest version is MOBILE6.2C dated May 14, 2003) (Environment Canada) to reflect differences in base emission rates for vehicles in Canada prior to harmonisation of emission standards. It includes differences in emission standards in Canada for pre-1988 light-duty vehicles and changes in the model defaults regarding the effectiveness of Consent Decree rebuilds of older engines from 90% to 0% (i.e., no rebuild program in Canada).

MOBILE is a well-recognised and recommended model to use for calculating on-road vehicle emissions and evaluating highway mobile source control strategies for on-road

vehicles. However, this model was not designed to calculate emissions from idling vehicles. The model only includes fuel consumption data for vehicles driven according to the Federal Test Procedure (FTP) that simulates an average urban cycle, which is significantly different from the fuel consumption of a vehicle idling for a long period of time.

The U.S. EPA is developing a new vehicle emission model called MOVES, or MOfor Vehicle Emission Simulator (US EPA, 2004). It is being developed for the estimation of emissions from on-road and non-road mobile sources and will have the ability to calculate emission factors for idling vehicles, as well as for vehicles during normal operation. However, the version of the model currently available, MOVES2004, only models emissions for N₂O and CH₄ and has been released as a beta test version.

Because the project targets idling emissions and not travelling emissions, some models face some weaknesses to address this specific manoeuvre. As a result, the three emission estimating models: EMFAC, MOBILE and MOVES were identified as the most common tools for estimating emissions from idling trucks. Of the studies reviewed, those that prepared inventories of emissions from sources operating at the Port of Long Beach (Starcrest, 2004) and the Port of Los Angeles (Starcrest, 2004b) used those factors. Institutions such as the California Air Resources Board (CARB) and the US Environmental Protection Agency (EPA) were then contacted for additional information.

After consulting with Megan Beardsley and David Brzezinski of the U.S. EPA (U.S. EPA 2005), it was concluded that the most suitable method for estimating greenhouse gas emissions from truck idling in Canada was to apply vehicle test data rather than existing computer modeling tools. There are several published reports containing emission factors for truck idling that simulate the impact on idling emissions of various parameters such as weather temperature, vehicles' age, accessory load and engine speed (high and low idle). Some of these reports do not calculate emission factors for CO₂, which narrows the available references to four studies.

In 2000, Argonne National Laboratory published a report analysing the effect of different technological options on fuel consumption of idling trucks (Argonne, 2000). This report included CO₂ emission factors (in g/hr) for idling conditions in different seasons of the year. The data in this report was based on vehicle test data measured by the American truck Association (ATA) in 1998.

In 2001, a study by the University of California-Davis analysed the possible benefits of using fuel cell technology to power truck accessories in idling situations (Brodrick et al, 2001). The CO₂ emission factors are based on tests performed on a single class 8 Freightliner Century class tractor with a 1999 year engine. The emission factors were generated for two driving situations, one based on a truck idling after a cruising cycle and the other measured after a transient cycle (more representatives of urban driving conditions). The factors are shown in Table 4-13.

Table 4-13: Idling Emission Factors Developed by University of California Davies

Mode	CO ₂ [g/hr]
Mode 1: idle after cruise	4034
Mode 2: idle after transient cycle	4472

In December 2003, staff from the California Environmental Protection Agency (CEPA) compiled testing data from several sources including West Virginia University, US EPA and ORNL (Oak Ridge National Laboratory). The study derived emission factors for several vehicle model years, with and without accessory load and at high and low idle engine speed (CARB, 2003). A normal idle engine speed can be around 600 rpm with no auxiliary loads, whereas if the air conditioning, cabin heaters, microwaves, etc, are operating, the engine idling speed can be as high as 1200 rpm. The emission factors from this study are summarised in Table 4-14.

Table 4-14: CO₂ Idling Emission Factors Published by CEPA (CARB, 2003)

Model Years	CO ₂ [g/hr]		
	Low Idle	High Idle (w/accessory load)	Average Idle (60% low and 39% high)
Pre-1975 to 2005	4366	9140	5846

This study based its factors on 'curb' idle, in other words, the idle that occurs in normal road traffic conditions. For the purpose of our study, this type of idling is not the most appropriate, because it does not occur for long periods of time.

The last report to be considered was published by the U.S. EPA in 2002. This study was conducted over a two-year period and involved a total of 42 tests on nine class 8 trucks, with model years ranging from 1980's to 2001. In each test, the vehicles were idling for the total of three hours in order to gather a representative sample of long idling conditions. The CO₂ emission factors from this study are given in Table 4-15.

Table 4-15: CO₂ Idling EFs Published by the U.S. EPA

Model Years	CO ₂ [g/hr]		
	Weighted Average (60% high idle and 40% low idle)	Weighted Average (70% high idle and 30% low idle)	Arithmetic Mean
1980 to 2001	9411	10012	8224

Sources: U.S. EPA, 2002.

The emission factors from this report are higher than the ones from the previous studies. It is important to note that the testing conditions in each study were slightly different. In the first of the studies referred to above the number of sampled vehicles was smaller and the tests focused on 'curb' idling emissions. The EPA study in 2002 was based on a higher number of tested vehicles and longer idling periods. Idle emissions appear to have an initial stage where levels have a high degree of variability until a plateau is reached. The three hours of the EPA tests ensured that various stages of idle were measured and included in a final average. The emission factors in this report were considered to be the most adequate for the port.

5 TELEPHONE INTERVIEWS AND SITE VISITS

5.1 Interviews

The telephone survey was carried out focusing on the ten busiest ports (and stakeholders) listed in Table 5-1. The purpose of these interviews and visit was to obtain information on the port and terminal management systems employed. The main priority of this study was to gather information on the impact of terminal automation technology and appointment systems on congestion and air pollution.

The interviews targeted terminal operators who have implemented appointment systems enabling truckers transporting containers to book time-slots for pick up and/or the delivery of a container. Phone interviews also provided data on operations, security systems and environmental programs, and confirmed web-gathered information.

Ten port authorities and their stakeholders (Container Terminal Operators) were contacted for the telephone survey and each received a written questionnaire for completion.

Unfortunately, the telephone survey was not successful as only eight (8) stakeholders out of 60 (initially identified) responded or agreed to participate. The remaining cited lack of time and interest or confidentiality. For the most part, phone calls and e-mails remained unanswered. Table 5-1 highlights the response from the stakeholders who participated in the interviews.

5.2 Site Visits

Based on the information obtained from web search and from contacts made through the telephone survey, visits to American and Canadian west coast ports were planned. The purpose of these visits was to obtain information on integrated ports /or terminals cargo information systems, terminal technologies and environmental programs.

Five port authorities, six terminal operators, one technology supplier and several stakeholders were visited within a five-day trip, from June 6th to June 10th, 2005. Table 5-2 shows the schedule and all contacts made throughout this trip.

Table 5-1: List of Participating Stakeholders – Interview Process

Company (Port/Terminal/ Other)	Interviewed Person	Highlights
Port de Montréal	Gaétan Vigneault	- Port Authority has no responsibility for system implementation at terminals.
Cast Racine Terminals – Mtl	Migo Kanondjian General Manager Operations	- Systems: Terminals have no appointment system in place and use a manual gate registration process. - 2 Systems: terminals using NAVIS (yard and vessel management system).
Port of Long Beach	Mr. Donald Snyder Director	- 22 Systems: no mandatory appointment systems imposed to terminals, and the use of one is not mandatory either. However, the implementation of the Lowenthal Bill for Southern California ports provided a good incentive for terminals to install an appointment system. - 23 In Southern California, about 80% to 90% of the terminals use the eModal or the Voyager software to enable truckers to set gate appointments. - 24 Extend gate hours: approach to help reduce the regional congestion from trade traffic. Majority of container terminals offer extended hours of service for carriers and shippers.
PANYNJ – APM Terminals (Port Elisabeth)	Richard Carthas Director Terminal Operations	- 1 Systems: Technologies such as GPS, OCR, CCTV, and RFID should assist in expediting cargo movements through the facility in the future. Terminals exploring the introduction of an appointment system to increase cargo handling efficiency and overall productivity. - 2 Environmental: Governed by the EPA guidelines. Regularly exploring opportunities to reduce primarily diesel emissions through the introduction of new equipment and engine technologies, low-sulphur fuels and diesel to electric conversion potential.
Port of Oakland and TransBay Container Terminal	Tim Leong Port Environmental Specialist and Truck Program Project Manager and Robert Bergmann	- 25 Systems: Appointment systems are currently in place for all terminals except one. Last terminal will be operation within the next month. - 26 Systems: 30% – 50% of the terminals use eModal. Others used proprietary appointment systems. - 27 Environmental: Incentives for truck drivers to replace old trucks with new ones. - 28 Environmental: Container yard equipment – upgrade engines, use of hybrid and electric engines, etc. - 29 Security: Some terminals have X-Ray scanners.
Vancouver Port Authority	Bob Hayter Shore Operations	- 30 Deltaport and Vanterm are operated by TSI Terminals Systems Inc. Centerm is operated by P&O Ports. All three terminals are operated under long-term lease from VPA. - 31 Systems: Deltaport is using NAVIS (management system) and other proprietary software, but are planning to switch to NAVIS.
Port of Seattle	Kent Christopher	- 32 Systems: eModal is installed on POS but truck drivers do not use it. The regulation allows a maximum of 30 minutes idling and they are usually under that time. - 33 Environmental: No anti-idling legislation imposed (state of Washington, not California) and newer equipment for yard trucks, top picks, etc.

Table 5-2: Visit Schedule, Contacts and Highlights

Date	Company (Port/Terminal/ Other)	Location	Interviewee	Comment
Jun 06, 05	Port Authority of Los Angeles – Environmental Department	Port of Los Angeles	Ms. Shokoufe Marashi and Mr. Kevin Maggay, Environmental Specialists	Presentation on Port of Los Angeles Air Quality Programs
	Trans Pacific Container Service Corporation – TraPac	TraPac Terminal, LA	Mr. Frank Pisano, VP and Mr. Daryl Hoshide, Terminal Operations Manager	Presentation and discussion on operational systems and technology currently in use.
	Maersk Sealand	Maersk Terminal, LA	Ms Konstantine, Director of Communications	Short presentation on terminal operations
	Port Authority of Long Beach – Trade and Maritime Services	Port of Long Beach	Mr. Donald Snyder, Director	Discussions on port operations and the necessity of a reservation system
	Centre for International Trade and Transportation (CITT)	Hyatt Hotel Long Beach	Mr. Thomas J. O'Brien, Director of Research	Discussed effectiveness of terminal appointment system
Jun 07, 05	eModal	SSAT in Long Beach	Mr. Gunnar Gose, Director Sales and Marketing	Overview of the eModal technology at SSAT
	Stevedoring Service of America Terminal (SSAT)	Long Beach SSAT Terminal	Mr. Pieter Suttorp, General Manager and Mr. Alan Bates, Terminal Manager	Discussed systems currently in operation (reservation system)
Jun 08, 05	Port of Oakland Marketing Division	Port of Oakland	Mr. Dan Westerlin, Special Assistant to the Executive Director	Presentation on port and terminal operations
	Port of Oakland Marine Division	Port of Oakland	Mr. Christopher Peterson, Wharfinger	Terminal visit and discussions on port operations
	Port of Oakland Environmental Department and Air Quality MD Enforcement	Port of Oakland	Mr. Jeffrey R. Jones, Environmental Compliance Supervisor and Mr Ronald S. Pilkington, Compliance and Enforcement Division	Discussed port operations and environmental programs
	Seaside Transportation Services (STS)	LLC Terminal Oakland	Mr. Chris May, Terminal Manager	Discussed terminal philosophy and automation systems currently in operation including mandatory reservation system.

Date	Company (Port/Terminal/ Other)	Location	Interviewee	Comment
Jun 09, 05	Port of Seattle	On-Site	Mr. Kent Christopher, General Manager Containers	Discussed terminal operations and toured terminal.
	Stevedoring Service of America Terminal (SSAT)	Terminal in Seattle	Mr. Lee MacGregor, General Manager	Discussed current and future systems
Jun 10, 05	Port of Vancouver – Trade Development Container	Port of Vancouver	Mr. Brian T. Yamaguchi	Presentation on current port activities
	Port of Vancouver – Shore Operations	Port of Vancouver	Mr. Bob Hayter, Manager and Mr Doug Mills, Coordinator	Terminal visit and discussion on operations
	Port of Vancouver – Environmental Programs	Port of Vancouver	Ms. Alicia Blancarte, Director and Ms. Christine Rigby, Environmental Specialist – Air Emissions	Presentation of current and future environmental programs
	Terminal Systems Inc. (TSI)	Delta Port Terminal – Vancouver	Mr. Nick Vancic, Operations Superintendent	Terminal visit and viewed in-yard operations.

The following paragraphs describe major highlights from conversations with port authorities and terminal operators.

Port Authority of Los Angeles – Environmental Department

The Port Authority of Los Angeles is in charge of all environmental issues within the port sector. The main issue of the Environmental Department is air quality. The programs include (but are not limited to):

- Replacing existing fuel for **Emulsified Diesel (Yard Equipment – tractors)**;
- **Vessel Speed reduction (since 2001)**: maintain 12 knots or less within the Air Quality Compliance Zone – Expected full implementation-reduction of three tons smog/day;
- **Alternative Maritime Power**: connecting Ships to Electric Power While at Berth (instead of using Ship Power) – Estimated Ship/Day Emission Reduction: 1,03 tons/day of NO_x and 0,58 tons/day of SO_x;
- **Port-Wide Air Quality Monitoring Program**: since February 4th, 2005, four stations are in place to determine the emission levels in proximity to the port that are due to the port operational activities.

Several other programs were discussed at the port to mitigate emission sources. Such programs include the Alameda corridor, the Pier Pass (which has now been implemented), Internet services for empty container accessibility, etc.

Port of Los Angeles – Trans Pacific Container Service Corporation (TraPac)

The TraPac terminal located in the Port of Los Angeles is a single user terminal (MOL shipping line); employing primarily grounded operations e.g. all containers are stacked and loaded directly on trucks by terminal cargo handling equipment.

Due to land size restrictions (175 acres), TraPac stores containers on the terminal in stacks. With the increase in container volume, TraPac faced challenges to increase productivity and ensure efficient container delivery.

The TraPac Terminal views the Appointment System concept as good in principle but feels that the truckers are sufficiently sophisticated to schedule time slots, and frequently end up missing appointments. Consequently the Appointment System is not predominately used, and the terminal management has focused instead on reducing labour costs and increasing productivity (moves/day). Their solution was to employ automation technologies to move containers more efficiently, and by increasing their container handling capacity and limiting the time containers spent in the yard. To do so, TraPac switched to RTGs as the main terminal cargo handling equipment. The terminal has also introduced integrated smart technologies such as OCR, RFID, GPS and more than 25 CCTV cameras. In addition, automated express gates were fitted with OCR and RFID to process trucks. As a result, operation efficiency and productivity (moves/day) have increased up to 7500 containers moved per day (previously 1500 – 1800 moves/day). Their expectations were to reach 10,000 to 15,000 moves/day when full implementation is completed. Thus truck waiting time at gate was reduced to an average of 10 minutes idling, whereas in the past it could take up to 6 hours for a truck to pick up a container. The terminal has largely eliminated gate queuing without the need of an appointment system.

Centre for International Trade and Transportation (CITT)

CITT is a partner with the University of Southern California in the Center for Metropolitan Transportation Studies (METTRANS). The METTRANS Transportation Center is a US DOT University Transportation Center (UTC). Established in 1998 through the Transportation Equity Act for the 21st Century (TEA-21), METTRANS is a joint partnership of the University of Southern California and California State University, Long Beach.

CITT has recently published an Evaluation Study of the Terminal Gate Appointment System at the Los Angeles/Long Beach Ports entitled 'The Terminal gate Appointment System at the ports of LA and LB: an Assessment, G. Giuliano et al, at the National Urban Freight Conference, held in Long Beach in February 2006.¹ The paper presents an evaluation of the appointment system implemented in 2002 in response to the Lowenthal Bill. The evaluation at the Los Angeles/Long Beach ports seeks to move beyond anecdotal evidence and gather actual data that can objectively guide policy decisions and make them as effective as possible.

¹ National Urban Freight Conference, held in Long Beach in February 2006.

Port of Long Beach – Stevedoring Service of America Terminal (SSAT)

The SSAT terminal of Los Angeles is configured for grounded operations employing on-road trucks (there is no on-dock rail operation). Cargo handling equipment such as RTGs and lift stackers is used to load containers on trucks.

SSAT implemented an appointment system in compliance with the Lowenthal Bill. Due to factors beyond their control such as wait time at other terminals and traffic congestion causing delays which affected their arrival time at the gates, only 10% to 20% of truckers set appointments. Given this low usage, SSAT did not organized their operations around fixed appointment time slots i.e. preparing containers to be "on-wheel" ahead of truck arrival time. It was not worthwhile to set up an appointment system due to numerous cancellations and to pre-mount "wheeled containers" at specific locations.

Alternatively, in order to increase turnaround time (currently has an average gate move/day of 2000), to reduce truck idling time and to increase security, SSAT invested in new automated gate technologies and integrated systems. OCR (gate) and integrating eModal systems such as scheduler, warehousing manager and a trucker database (plate and licence) are a few of the technologies considered. The terminal has introduces integrated smart technology such as OCR, and RFID to improve gate productivity. Automated express gates are fitted with OCR to process trucks and achieve accuracies in excess of 90 percent. The terminal has largely eliminated gate queuing without the need of an appointment system.

However, increased automation often creates conflicts with unions. Given the company's policy to keep good relationship with employees, the implementation of new technologies had to be done in phases. SSAT had planed to have the OCR technology and readers on cranes by the end of 2005.

Port of Oakland – Environmental Department and Air Quality MD Enforcement

The Port of Oakland recognizes the burden of the increase in goods movements, intensifying truck congestions, idling and air emissions. One of the main targets of the port to address these issues is to improve rail transfer, therefore increasing vessel to rail exchange and inland port intermodal usage.

The Port Authority had reservations on the success of the mandatory appointment systems. They noted some shortcoming of a system designed to meet the requirements of the terminal operators rather than the trucking companies' needs. As such, trucking companies have difficulties setting appointments 24 hours ahead of time, which is a condition for the use of most appointment systems that are available on the market.

Throughout the years, the Port of Oakland has been proactive for preserving air quality since the late 90's. As part of a program entitled "Vision 2000 Maritime Development Program", an Air Quality Mitigation Program (AQMP) was developed. This AQMP included nine main projects to reduce air emissions from the port land sources. One of the items of the program included the Fleet monitoring program or truck program which was an incentive for truck drivers to replace their old trucks (older than 1986) or old engines with new(er) ones. Despite the great funding of this program, it unfortunately did not generate the success expected because of the remaining cost the truck drivers still had to take on.

Port of Oakland – Seaside Transportation Services (STS)

STS are proactive in promoting the gate Appointment System (Premier system of ESC) and have integrated it into their operations in conjunction with gate automation technology. STS have made the use of reservation systems mandatory for truckers. Thus an appointment was required for a truck to pick up a container and without a reservation a truck would not be able to enter the gates. STS have adjusted their appointment system to make it flexible for truckers and/or trucking company. It is therefore not required to set an appointment 24-hrs ahead, 1-hour or even 15-minutes may be enough depending on gate accessibility. As such, reservation may be made by phone, fax, e-mail or on the terminal's Internet website. Their success depended on winning over the truckers by providing them with preferred access and no waiting at the gate. Also, to avoid truckers to not show-up at a set time slot, the reservations are made on a container basis. In other words, appointments are set for a container pick up as opposed to a truck arrival. This avoids a truck or a trucking company making several appointments over the same day to pick up one container.

To improve gate fluidity, STS integrated automation technology in the terminal operations, such as OCR at gates and on their ship cranes and CCTV cameras. This technology replaces checkers at gates and was primarily implemented to eliminate drivers/gate clerk interaction and reduce labour costs (65% of terminal overall costs). For terminal in-yard operations, STS rely primarily on RTGs for loading containers on trucks. With over 50% imports being grounded require keeping the trucks moving to maximize the productivity of the cargo handling equipment.

Port of Seattle

Located in Seattle, the seaport terminals are not under the requirement of having appointment systems since the Lowenthal Bill as the Bill only applies to California State. No terminal has implemented an appointment system to manage gate operations. However, several other programs to mitigate air quality issues within the Puget Sound region have been developed. Those relating to freight operations within the port include:

- The redevelopment of seaport cargo terminals to increase efficiency, including improving nearby road networks;
- The coordination of draw bridge openings with truckers so they can route accordingly to minimize idling;
- The pilot of computer tracking systems at our cargo terminals to quickly locate containers and thus reduce truck wait times;
- The installation of electric plug-ins instead of diesel units for refrigerated containers on the docks;
- The purchase of bigger cranes to load and unload more efficiently, so ships are at the dock for less time;
- The conversion of all seaport cargo cranes from diesel to 100% electric;
- The partnering to regional anti-idling effort.

Port of Seattle – Stevedoring Service of America Terminal (SSAT)

The SSAT terminal of Seattle completed a major expansion in the spring of 2002. T-18 is now the port's largest container terminal and one of the largest in North America. Redevelopment of adjacent property doubled the size of the terminal.

SSAT carries grounded and rail operations. They have doubled their intermodal container rail capacity in 2004, which enables cargo to be moved directly onto railcars. Concurrently, SSAT improved access to container terminal by rail and road grade separations and route changes (efficient road access via truck overpass, avoiding rail crossing roads).

SSAT implemented an integrated real-time computer software system for vessel, rail and gate operations in order to improve decision making for every facet of terminal operations. This was done in conjunction with automation technology including OCR RFID and CCTV cameras. Fixed X-ray devices are installed at the main gate. Located in Seattle, this terminal is not under the requirement of having an appointment system as the Lowenthal Bill applies only to California State.

Port of Vancouver

The Port of Vancouver was the first port in North America to mandate the use of appointment or reservation systems at their container terminals. The system was implemented in 1999 (following a trucking dispute with the owner-operators) in an attempt to reduce line-ups at the gate. The main incentive was a reduction of truck waiting time, which could be as high as three hours and limited the number of transactions done during the day by truckers. With its implementation, queuing time has dropped to less than 30 minutes in average while the number of TEUs increased from 900,000 in 1999 to 1,800,000 in 2005.

However, the appointment systems still faces some challenges, notably the handling of truck cancellation, the handling of trucks not showing-up for their appointments and the management of appointments resulting from delays at railway crossings due to train operations. The Port Authority has supported the introduction of the mandatory reservation systems citing it helped smooth trucking flows and reduced queuing at the gate. The Port Authority acknowledged some the difficulties due to a changeover from an in-house computer platform to a third party software provider. These situations create frustrations for both the terminal and truck owner-operators, however given the success of the systems; all agree to pursue this practice, as a withdrawal could not be acceptable. Also, to help reduce waiting time, the terminals have extended their gate hours for container trucks. Both TSI and P&O Ports, Vanterm terminal operate a reservation system.

Some logistics problems were also faced such as lack of drayage trucks drivers, chassis, container status reporting, truck order processing, empty container moves, container tracking, etc. In addition, the September 11th, 2001 terrorist attacks required a good security system to be installed.

The following mitigation measures have been implemented at the port to overcome the above-mentioned issues:

- All South shore access at the Port of Vancouver are controlled by a Vehicle Access Control System (VACS) including a Card Access Management (CAM) and changes according to the security level. The technology is using RFID tags allowing trucks, which respond to the classification system to be automatically identified at the terminal/port gates. Future steps will be to integrate all rail activities, truck reservation system (actually owned and managed by the terminals) and to transfer information via EDI to the VACS system;
- A new control room to gather all images from cameras installed at the different access;
- A Pacific Gateway Portal (PGP) web-base interface (community information system) to users for real-time cargo information, vessel activity, container status as well as driver validation (CAM).

Container terminals are using mostly in-house yard management systems, but TSI at Deltaport had planned to switch to NAVIS by the end of 2005.

The Port Authority has integrated or studied the application of innovated technologies such as Shore Power, O2 Diesel, Water Injection, CombustAll, Biodiesel, etc. in view of reducing emissions from major sources at the port. The Port Authority also conducted studies on rail systems and on approaches to reduce congestion in urban streets.

Finally, the Port Authority is currently in the process of completing a baseline emission inventory, therefore compiling information about air emissions and the contributions of marine, truck and rail traffic and terminals; quantifying reductions achieved in the last 5 years due to operational and technological improvements and developing a process to quantify emissions credits and establish baselines.

Port of Montreal

The Port of Montreal's Gateway Terminals CAST and Racine have not currently implemented a gate reservation system. At the terminal gate, truck and driver validation is done as well as container and chassis inspection. Last April, CAST and Racine adopted extended operating hours e.g. fro 0600 to 2300h; however the initiative was not successful in shifting truck traffic from peak hours since the distribution centres were not open during the late evening.

Montreal's Gateway Terminals do not use automation technologies at gate (entrance and exit) such as OCR, CCTV camera, or other automated system to facilitate authorization, processing and registration of trucks and drivers.

However, CAST Terminal uses NAVIS as a vessel planning and yard allocation management system. CAST Terminal represents a baseline benchmark for terminals not using automation technologies at the gate.

To evaluate the actual waiting (idling) time at this terminal, an interview with CAST terminal officials revealed an average turn around time from check-in (terminal entrance) to the terminal exit gate, of 20 to 25 minutes and idling ranges outside the terminal of five to ten minutes, depending on the time of day. Of the total average time, the total time spent travelling in the terminal needs to be subtracted.

Travel time at the CAST terminal was estimated at around two minutes, as trucks travel approximately 500m (surface area of 62ha) at a speed of 20km/h – maximum speed allowed on the port's premises, making the total time spent idling ranges from 23 to 33 minutes at that terminal. For the purposes of calculating GHG emissions, the average time of **28 minutes** will be used.

6 FINDINGS FROM REVIEW, INTERVIEWS AND VISITS

The literature review, interviews and visits to west coast ports and terminals examined measures to reduce GHG associated with port activities. The resulting findings indicated that implementation of terminal automation technology and environmental legislation (e.g. Lowenthal Bill) had an appreciable impact in curtailing truck waiting (idling) at container terminals.

In California, prior to 2003, container terminals suffered from truck queuing with idling time reaching up to six hours. Terminal productivity, truck turnaround time, public road congestion and air quality were all impacted by this situation:

- Turn around time for trucks usually exceeded one hour and could be as high as six hours;
- Terminals closed their gates at 2 p.m. to address trucks that were in queue at the terminal gate before the night;
- Terminal land area had stacked containers to full capacity, which delayed the unloading of vessels and the loading of container trucks.

In 2003, the Lowenthal Bill was implemented in California, which seeks to reduce vehicle emissions and highway congestion, by reducing truck queuing at marine terminals and distributing truck traffic from peak hours to over the entire day. The Bill permits terminals to implement appointment systems or off-peak operating hours as a means to avoid fines for truck queues. As a result of the legislation, appointment systems were implemented in over 90% of California terminals.

Different approaches have been used to address truck idling at terminal gates. In fact, some terminals have implemented technologies, resulting in increased productivity, labour reduction, and a decrease in idling and emissions.

One successful strategy to increase terminal productivity was the implementation of technology (i.e. TraPac Terminal, LA). Terminal management focused on increasing productivity (gate moves/day) through increasing automation and reducing labour costs. In other words, the terminal introduced integrated smart technology such as OCR, RFID and GPS. The automated express gates were then fitted with OCR to process trucks and highly efficient cargo handling equipment was installed (i.e. rubber tired gantry (RTG) cranes).

6.1 Terminal Appointment System

The Appointment System concept is container specific and is used primarily for import containers associated with grounded terminal operations. The terminal sets limits on the number of trucks allowed entry into the yard. The terminal can also pre-position or pre-mounts containers (e.g. wheeled operation) to reduce waiting and consequently idling time.

The success of terminal appointment system implementation essentially relies on winning over truck drivers by providing them with incentives and clear benefits. For the

trucking community the key benefit is higher productivity resulting from faster turnaround time. For the terminals the greatest incentive is the ability to plan the moves per day based on capacity. This process involves working with the trucking industry establish each party's requirements for a successful system. To ensure the successful function of the appointment system it is important that it be integrated into the terminal operating system. The TOS contains the location of all containers, the operations schedule and the business rules by which the terminal operates. Discussions with the terminal operators indicated that the biggest problem to a successful implementation were not technical but rather human reluctance to embrace a new way of doing business.

Finally, appointment systems implemented in conjunction with extended gate hours and technologies (OCR, CCTV cameras and RFID) enjoy higher success rates. Automation technology provides further container identification and increases security and cargo tracking and reduces truck idling times at the gate.

The systems must set appointments to the most appropriate factor. For instance, appointment systems that evolve around reserving a time for truck arrivals are exposed to greater cancellations and/or multiple appointments for a single container than those that evolve on a container basis. Appointment system which set appointments on a container to be picked-up provide truck drivers greater flexibility and allows terminals to receive appointments less than 24 hours in advance. It also prevents "overbooking".

6.2 Pier Pass Program

To alleviate long truck queues, several terminals extended their gate hours into the night. This option did not readily remedy the situation because truck drivers had double transactions to complete and the second transaction often took place at other terminals whose gates were closed in the evening. This prompted the initiative of the Pier Pass program, which provide for night operation to relieve the pressure on highways during the peak daytime periods.

The Pier Pass program implemented on July 23rd, 2005 is an incentive by the cargo owners to move cargo at night and on weekends to reduce truck traffic and pollution during peak daytime traffic hours and to alleviate port congestion. This involved all terminals in the LA-LB ports to coordinate their gate hours to be opened during nights and weekends, allowing trucks to pick up and off-load their containers. The project is enforced with premiums set in place for transactions completed during the night.

The program appears to be a success since ten weeks following its implementation, more than half million-truck trips had been diverted from peak daytime traffic. Noticeable relief in congestion on public freeways has been observed: according to a study by the Alameda Corridor Transportation Authority (ACTA), during peak-hours truck traffic dropped of about 24%. Significant decrease in traffic congestion has also been perceived inside the Ports of Los Angeles and Long Beach.

Additionally, operations within terminals during the new Off-Peak shifts are as efficient as daytime shifts and truck drivers have been able to increase their productivity (58% of truck drivers say they are able to make more cargo trips a day).

Pier PASS was honoured on November 10th, 2005 by the Harbour Association of Industry and Commerce (HAIC), a collective voice for the harbour business community

on economic, environmental, and public policy, for its progress in relieving cargo congestion in and around the Ports of Los Angeles and Long Beach.

On the other hand, the trucking industry has complained over the congestion at the beginning of night time off-peak shifts. It appears that at the start-up time of the service (6:00 p.m.), lots of trucks show-up following the same tendency that used to occur at 7:00 a.m. prior to the program. Although a reduction of activity is observed after the 10:00 p.m. to 11:00 p.m. meal break even though the off-peak shifts continues until 3:00 a.m. A few weeks after the implementation of PierPASS, a majority (47%) of truck drivers reported positive feedback, 38% were negative and 15% remained undecided or split.

6.3 Other Environmental Programs

With the Kyoto protocol, the emergence of environmental concerns regarding climate change and with the raising concerns on smog forming and health concerns, it has become a social, political and economical requirement to address emissions from ports and terminals.

Most ports are aware of their contribution to regional air emissions and GHG emissions and are taking action to address these issues, especially those located on the West Coast. Table 6-1 summarises some of the actions undertaken by ports to reduce air emissions from their major sources, which includes Ocean Going Vessels (OGV); Harbour craft; Cargo handling equipment; Rail (locomotives); and Container trucks.

This table does not take into account the technologies implemented to increase productivity even though indirectly, by achieving greater efficiency, reductions of truck idling time and therefore truck emissions are obtained.

Table 6-1: Air Quality Mitigation Actions Taken by Ports

Sources/Target	Actions
General (throughout the ports)	Port-wide emission inventory which includes identification of emission reduction methods and assessment of the implications of the Kyoto protocol on all aspects of port operations.
	Air quality monitoring.
Ocean Going Vessels	Speed reduction program.
	Cold-ironing ^a program or Alternate Maritime Program (LA, LB, Oakland).
	Berth allocation systems to reduce the amount of time ships spent in ports.
	Use of alternative fuel.
	Improved bunker fuel used (to come).
Yard Equipment Program	Retrofit engine technologies.
	Emulsified fuel.
	Electrical engines.
Rail	Retrofit locomotives with cleaner-burning diesel engines, or replace the engines with cleaner models (reduction of 20 t NOX/yr/engine).
Container trucks	Regulations (e.g. Lowenthal Bill).
	Premiums for transits during the day.
	Truck Program: Retrofit, replace or re-power HDV engines.
	Others.

a: cold ironing: Rather than using the vessel's auxiliary internal combustion engines to provide electrical power while docked at ports, cargo vessels could use shore generated electric power, exhaust controls on auxiliary engines and/or using cleaner-burning fuels in auxiliary engines.

Emissions associated with truck idling that occur at the beginning and end of trips are usually not included in emissions inventories. However they can be an important contributor to the overall mobile source emissions and have an impact on the idling issue at terminals. To address these, ports have – or are looking at – putting in place the following programs:

- *Warehouse hours coordination:* To allow truckers to load and unload their container during nights and weekends (Pier Pass project), coordination with warehouse hours is needed.
- *Alameda Corridor Truck Expressway (LA, LB):* This project involves building a viaduct connecting the terminal area to the Alameda street, providing a much more efficient and safe route for container trucks. This elevated expressway would eliminate five at-grade crossings and three signalized intersections, thus significantly alleviating traffic on public roads.
- *Virtual container yard.* An Internet service is proposed to reduce the movement of empty import containers travelling back and forth between the port and off-site warehouses. This can account for up to 75% of the trucks travelling time. The initiative consists of an Internet service to match empty import container with exporters requiring containers to be stuffed. In lieu of sending empty containers from the distribution centre back to the port they would be sent to potential users located in the same area.
- *Advanced Transportation Management, Information and Security System (ATMIS):* ATMIS should improve traffic flow for both ports and adjacent regional transportation, and improve safety and security at ports.

Several other programs are being discussed and/or have even been implemented in North America. The ones listed in this section give a general overview of what has and can be done to address the issue.

7 CANADIAN STRATEGY FOR REDUCTION OF GHG AT TERMINALS

7.1 Context

As a result of increasing container volumes and vessel delays terminal operators are facing increasing gate congestion and the associated pollution. New anti-pollution legislation such as the Lowenthal Bill requires container terminal operators to pay a fine whenever the on-road trucks idle in excess to of 30 minutes. Terminal operators are turning to appointment systems to ease gate congestion and allow a smooth flow-through of traffic. Various vendors of cargo information and management systems have integrated the appointment system into the terminal operating systems. The goal is to move containers more efficiently and minimize the time trucks spend at the gate and in the yard (Waiting Time). The basic premise for the use of appointment systems is to match the number and frequency of trucks with the total gate and yard capacity to process containers. Appointments are then allocated to truckers for specific time slots. This results in a smooth flow of traffic, maximizing individual truck turnaround time and minimizing gate congestion.

An emission calculation method has been developed to quantify the GHG reduction potential of appointment systems and gate automation technologies. The two approaches are illustrated Oakland, STS and LA, TraPac terminals as examples of where gate reservation system and gate technologies are employed. This provides some metrics whereby the efficacy of different approaches to reduce GHG can be evaluated.

An example is given, on how appointments and automation technologies integrated within the terminal operation systems (TOS) can affect the turnaround time of drayage trucks and reduce GHG. The following aspects are examined:

- Estimated Current Travel Time;
- Estimation of GHG – Current Scenario;
- Impacts of Technologies on Reducing GHG Emissions;
- Projected Impact of Technologies on GHG Emissions;
- The reductions in truck travel time segments outside and within the container terminal are indicative of GHG emissions reduction

7.2 Estimated Current Travel Time

The trajectory of a typical truck transaction, i.e. the pick-up of an import container, can be broken down into a number of time steps. In addition, drayage trucks can have different paths and cover different distances when they enter the terminal, depending on if they are:

- Picking up a chassis with import container (wheeled container);
- Dropping off empty container;
- Picking up an import container in the stack.

The state of the container (full or empty) can also influence the path of the truck in the terminal. With an empty container the truck will have to go through different procedures at the gate and take a different path within the yard. For the purpose of illustration, we will establish that all container trucks are doing the same single transaction e.g. pick-up of an import container.

Figure 7-1 shows the typical path of a container truck that processes through a container terminal:

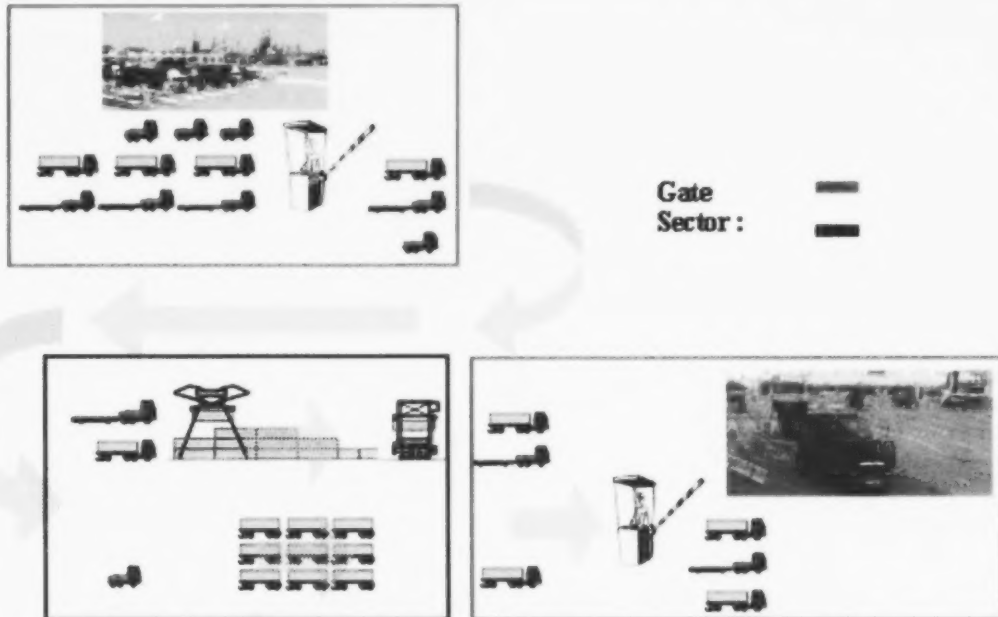


Figure 7-1: Typical Container Truck Path at Container Terminal

The truck route has been divided into ten time segments (Turn around time) each representing moving and/or waiting periods described below.

Considering that the use of technologies and terminal operation systems (TOS) can affect container truck segments by reducing the turn around time, the periods named with a prefix "X" cannot be reduced with the use of technologies. These time periods are considered fixed.

On the other hand, the periods of times without the prefix "X" could be reduced by technology.

- T_1 Waiting period resulting from a disruption preventing access (train crossing) to the entry gate of the terminal – (truck is idling);
- T_2 Waiting period resulting from having to wait in a queue to access the terminal gate (truck is idling);
- T_{3X} Travel period required to arrive at the terminal gate (Entrance Gate);
- T_4 Waiting period required while the delivery slip is reviewed and during check-in (container, truck, driver) (Truck is idling);

- T_{5X} Travel period for proceeding to the gate (Pedestal Gate) for validation and instructions;
- T_6 Waiting period for the data validation (truck, trucker and container ID) and receipt of instructions from gate's clerks (truck is idling);
- T_{7X} Travel period for entering the terminal and reaching container stack;
- T_8 Waiting period for loading a container on the truck using the appropriate CHE (Forklift, RTG, etc.) (Truck is idling);
- T_{9X} Travel period for proceeding to the exit gates for verification and validation;
- T_{10} Waiting period while waiting in a queue to exit the terminal (Truck is idling);
- T_{11} Waiting period for validating and verifying container data (Truck is idling);
- T_{12} Waiting period required for a random, thorough inspection of the container's contents by Customs Officials (Truck is idling);
- T_{13X} Travel period to leave for the terminal area immediately past the terminal's exit gate.

Figure 7-2 gives an illustrative example of these ten periods in which trucks go through for a gate-to-gate operation. Each segment of the trajectory corresponds to a container truck segment. The plateaus in the graph correspond to waiting time with the truck idling, which the application of technology could reduce.

The time indicated on the Y (Distance traveled) and X (Cumulated travel time [minutes]) axis are only for the sake of the illustration and do not correspond to any example or scenario that will be discussed later on.

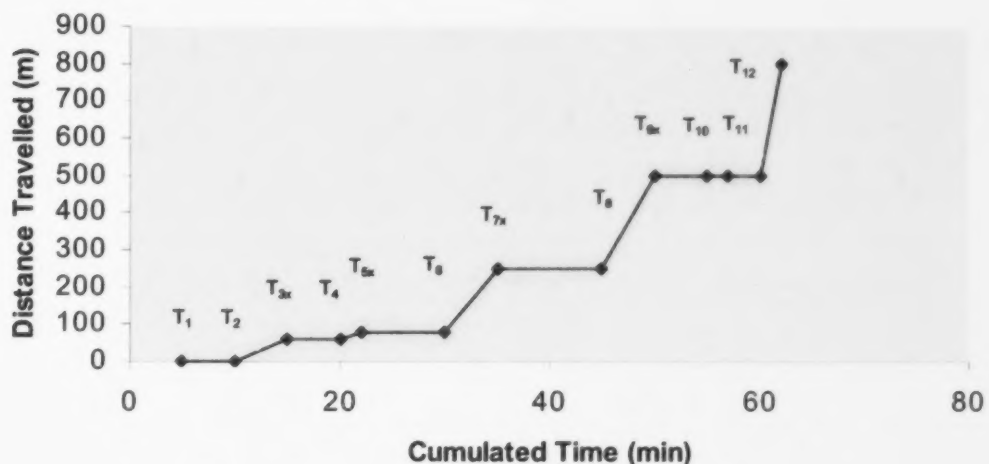


Figure 7-2: Time Space Curve of a Truck Route

Measures applied in practice allow the determination of the length of waiting and travelling times when considering the typical truck path in a container terminal. Data set out in a space-time diagram reveal very similar patterns, as shown below.

For GHG emissions calculation purposes, the entire truck route would be reviewed, however, it was agreed that **only waiting times** (when the truck is idling) would be used in the calculation. This decision is based on the following considerations and hypotheses:

- Travel times in vicinity of the container terminal depend on real traffic and time management by the truck drivers. Truck drivers are therefore responsible for getting to the terminal on time, regardless of traffic constraints;
- Travel times within the terminal yard are relatively constant. They cannot be appreciably reduced through the introduction of technologies (the physical layout of the terminal has a greater impact in this respect).

Time spent travelling is considered to be constant and excluded from the calculation of interest.

The following will also be excluded from the calculation: waiting period resulting from disruptions (T_{1x}) and Customs inspections (T_{12x}). This time is unknown and no data or average times are available.

The calculation of the current travel time ($T_{Current}$) of a container truck still has to take six of the ten factors into account, as set out in the formula below (the definition of the terms are the same as those specified above in the beginning of section 7.2):

$$T_{Current} = T_2 + T_4 + T_6 + T_8 + T_{10} \quad (1)$$

For the purposes of comparing, analysing and calculating results for the various terminals selected, the circumstances of the Port of Montreal's CAST terminal, Los Angeles's TraPac terminal and Oakland's STS terminal were reviewed. These three terminals present very different and opposing state of affairs.

7.2.1 Port of Montreal's CAST Terminal (2005)

CAST terminal uses NAVIS as a vessel planning and yard allocation management system. However, CAST terminal does not employ:

- A reservation system for truckers and manually processes the verifications/validation of containers, drivers and trucks;
- Automation technologies at gate (entrance and exit) such as OCR, CCTV camera, or other automated system to ease the process of registration and verification.

CAST terminal represents a point of reference for terminals not using gate automation technologies or reservation systems.

To evaluate the actual waiting time at this terminal, an interview with CAST terminal officials revealed an average turn around time from check-in (terminal entrance) to the terminal exit gate, of 20 to 25 minutes and waiting time ranges outside the terminal of five to ten minutes, depending on the time of day. Of the total average time, the total time spent travelling in the terminal needs to be subtracted.

Travel time at the CAST terminal was estimated at around two minutes, as trucks travel approximately 500m (surface area of 62ha) at a speed of 20 km/h – maximum speed allowed on the port's premises, making the total time spent waiting ranges from 23 to 33 minutes at that terminal. For the purposes of calculating GHG emissions, the average waiting time use when the truck is idling will be **28 minutes**.

7.2.2 Los Angeles TraPac Terminal (2005)

Prior to the introduction of the appointment system the effects of increased on-road truck traffic resulted in major congestion and associated pollution at the terminal. TraPac decided less than a year ago to employ automation technologies such as OCR, RFID at gates and also acquire in-yard cargo handling equipment (reach stackers, RTG, etc.) allowing it to increase the efficiency of their operations and as such considerably reduce waiting times at gates and in the yard. The following scenario existed prior to the implementation of the Lowenthal Bill requiring the mandatory reduction of diesel emissions at ports by limiting waiting time idling for trucks conducting transaction at California ports:

- **Truck traffic congestion at terminal gates (up to 120 min):**

When trucks arrive at terminal gates, the trucker registration and identification process was relatively long and complicated because data was treated manually and inspection of the container was done by a gate clerk. Secondly, language was also a problem since most truck drivers are of Hispanic descent and speak very little English. Clerks had a hard time understanding the information relayed by truck drivers.

- **Long delays inside the terminal (up to 180 min):**

Following the exchange of information with the gate clerk at entry gates, the trucker was ready to proceed to the transaction area inside the terminal (in-yard). To do so, there were long delays before a yard operator arrived to flag the trucker and escort him to the loading zone in the yard. Once they arrived, the trucker then had to provide information about his cargo to the yard operator. From that point, loading operations would begin and there would usually be delays before being completed.

Cargo handling operators had to locate the container, move other containers around and then manoeuvre to trans-load the designated container onto the truck chassis. The operation was just as time-consuming for container delivery.

Altogether, the yard operator and the trucker had to face delays for each transaction that took on average 300 minutes (5 hours).

Mainly for those reasons, TraPac put in place technology, such as GPS, more than 25 cameras and automated express gates fitted with OCR and RFID to decrease truck processing time and delays for truck drivers.

In an ultimate goal to improve the efficiency of operations as well as shorten delays and traffic congestion at gates, different integrated in-house systems were also implemented. In the event of equipment addition or replacement, operations can be carried out in an efficient manner by both CHE operators and truck drivers.

Key systems implemented that were observed during our visit are:

- In-house appointment systems for truck drivers (and trucking companies) allow them pre-registration and make reservations for specific time-slots. The appointment system features truck, trucker and container (or lack of) pre-registration prior to truck arrival at terminal gates. Appointments can be made by phone, fax or e-mail. This system allows truck drivers with appointments quicker access to gates. Entering through a dedicated lane provided for appointment trucks, the trucker registers upon arrival and enters the terminal. According to TraPac terminal authorities, this system is not used very much since delays were reduced with the help of new technology, which also decreed turn around time. They consider that the system is a response to the Lowenthal Bill and purely cosmetic.
- An automated registration management system (assisted) connected to a database allows a trucker (with or without an appointment) to register on a touch screen/key-board terminal. This ends the problem of languages since there is no interaction with gate clerks, except for requests or data processing problems. TraPac authorities mention that implementation was difficult. A lengthy confrontation ensued with different unions, who were against the elimination of clerk jobs. From six jobs initially, TraPac now has only one gate clerk dealing with requests and terminal gate monitoring.
- An in-house container management system in the terminal area including a database listing and locating all containers.
- Automation technologies such as GPS, fixed cameras, OCR, RFID installed on all cargo handling equipment (cranes, RTG, forklifts, gantry cranes, etc.) manoeuvring containers, feeding the container management system database in real time. Once processed, this data can be forwarded in real time through message radio or text message displayed on an LCD screen installed aboard cargo handling equipment.
- TraPac also views in real time all gates and terminal areas using more than 25 mounted and automated cameras. The images are sent to a management centre but some administrators can also have access (using a password) to the different images on the Web from their workstation. This allows quick and efficient response-time.
- In addition upon request from United States customs, an x-ray system is available. This tool displays the inside of containers without the need to either open or move the containers.

TraPac terminal has a voluntary reservation system in place. However, truckers are not using it because validation and verification of containers, drivers and vehicles are processed very fast at the gate. The terminal uses integrated technology at the gate (entrance and exit) and in the yard for container moves.

TraPac terminal has applied state-of-the-art technologies at the gate and in the yard and can be considered as a leader in this area. TraPac terminal officials said the average turn around time from check-in (terminal entrance) to the terminal's exit gate currently takes less than 30 minutes and that the waiting time idling outside the terminal ranges from zero to ten minutes, depending on the time of day.

Travel time per transaction at the TraPac terminal was estimated at around four minutes, as trucks travel approximately 1000m (surface area of 170ha) at a speed of 10mi/h (16km/h) (maximum speed allowed on the terminal's premises), making the total waiting time spent idling ranges from 26 to 36 minutes at that terminal. For the purposes of calculating GHG emissions, the average waiting time spent idling will be of 31 minutes.

7.2.3 Oakland STS Terminal (2005)

As a result of constant congestion problems at gates, with trucks sometimes waiting up to five hours before entering the in-yard, authorities decided to implement an appointment system for truck drivers.

Conversely to TraPac who chose to concentrate on gate and yard automation operations STS chose to implement the gate appointment system to reduce truck waiting time idling. They had observed major problems at terminal gates and were aware of the time limit for one single container trans-loading operation, which, before the appointment system was introduced, took from 20 to 30 minutes. STS elected to focus on terminal gates by making appointments through a mandatory reservation system.

The introduction of such a system under those conditions was a demanding task. Authorities worked very hard and had to negotiate with the trucking industry (unions). Allowing for certain flexibility, truck drivers can reserve a place up to five minutes before the end of the reservation period (time slot) either by phone, fax or e-mail

The STS terminal has a mandatory reservation system in place and requires all trucking companies to use it. It became very easy for truckers to process the container and truck, and clear the gate. They do not use a lot of technology at the gates (entrance and exit), but some for in the yard for tracking containers.

Of the terminals visited, STS at Oakland has applied the appointment system to its fullest potential and can be considered as a leader in the application and operation of an Appointment System. STS Terminals have made good use of this system to improve gate efficiency and increase trucker's moves per day.

STS terminal officials said the average turn around time from check-in (terminal entrance) to the terminal's exit gate currently takes around 20 minutes and that idling outside the terminal ranges from 0 to 20 minutes, depending on the time of day.

Travel time per transaction at the STS terminal was estimated at around four minutes, as trucks travel approximately 500m (surface area of 68ha) at a speed of 10mi/h (16km/h) (maximum speed allowed on the terminal's premises), making the total waiting time spent idling ranges from 18 and 38 minutes at the terminal. the average waiting time spent idling will be of **28 minutes**.

7.2.4 Overview of the Current Situation

Table 7-1 below shows the current data gathered during our visits to the above-mentioned terminals.

Table 7-1: Tcurrent Waiting Time at Terminals Visited

Terminal	Current Waiting Time (Truck idling)(min)	Average(min)
CAST, MI	23 – 33	28
TraPac, LA	26 – 36	31
STS, Oakland	18 – 38	28

These data will be used as input in the calculation of GHG emissions.

7.3 Estimation of Greenhouse Emissions – Current Scenario

Container trucks idling in port areas, i.e. vehicles with the engine running, stationary or moving slowly in a queue are usually waiting for terminal entry to pick up or drop off cargo. This study covers diesel-fuelled truck emissions since the percentage of trucks fuelled by gasoline is comparatively small.

The interviews and visits carried out at the beginning of this project indicated that the most common types of container trucks travelling within the port area are loaded container trucks, empty container trucks and bobtail trucks (disregarding on-site cargo handling equipment).

7.3.1 Calculation Methodology

The greenhouse gas emissions estimated in this study are carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), which are the most common greenhouse gases (GHGs) for combustion sources. Greenhouse gas emissions were estimated using a methodology appropriate to each of these gases, as discussed in section 4.

Emissions of greenhouse gases are reported individually and as the total equivalent mass of CO₂ (termed CO₂E). The conversion of the individual greenhouse gas emissions to CO₂E is based on Global Warming Potential (GWP) factors, which estimates the amount of heat-trapping potential for any given GHG within the atmosphere over a 100 year period. The GWP factors take into consideration the different length in time a GHG resides in the atmosphere and are listed in Table 7-2.

Table 7-2: Global Warming Potentials and Atmospheric Lifetimes

GHG	Formula	100-year GWP	Atmospheric Lifetime
Carbon Dioxide	CO ₂	1	-
Methane	CH ₄	21	-
Nitrous Oxide	N ₂ O	310	-
Sulphur Hexafluoride	SF ₆	23,900	3,200
Hydrofluorocarbons (HFCs)			
HFC-23	CHF ₃	11,700	264
HFC-32	CH ₂ F ₂	650	5.6
HFC-41	CH ₃ F	150	3.7
HFC-43-10mee	C ₅ H ₂ F ₁₀	1,300	17.1
HFC-125	C ₂ HF ₅	2,800	32.6
HFC-134	C ₂ H ₂ F ₄ (CHF ₂ CHF ₂)	1,000	10.6
HFC-134a	C ₂ H ₂ F ₂ (CH ₂ FCF ₃)	1,300	14.6
HFC-143	C ₂ H ₃ F ₃ (CHF ₂ CH ₂ F)	300	1.5
HFC-143a	C ₂ H ₃ F ₃ (CF ₃ CH ₃)	3,800	3.8
HFC-152a	C ₂ H ₄ F ₂ (CH ₃ CHF ₂)	140	48.3
HFC-227ea	C ₃ HF ₇	2,900	36.5
HFC-236fa	C ₃ H ₂ F ₆	6,300	209
HFC-245ca	C ₃ H ₃ F ₅	560	6.6
Perfluorocarbons (PFCs)			
Perfluoromethane	CF ₄	6,500	50,000
Perfluoroethane	C ₂ F ₆	9,200	10,000
Perfluoropropane	C ₃ F ₈	7,000	2,600
Perfluorobutane	C ₄ F ₁₀	7,000	2,600
Perfluorocyclobutane	C-C ₄ F ₈	8,700	3,200
Perfluoropentane	C ₅ F ₁₂	7,500	4,100
Perfluorohexane	C ₆ F ₁₄	7,400	3,200

Source: (Environment Canada, 2003)

In equation form, the conversion of the individual GHG emissions to CO₂E is expressed by:

$$CO_2E(\text{tonnes}) = CO_2\text{tonnes} \times 1.0 + CH_4\text{tonnes} \times 21 + N_2O\text{tonnes} \times 310 \quad (2)$$

Almost all carriers picking up or loading a cargo in the port area are diesel fuelled. Therefore, all trucks used diesel rather than gasoline emissions factors.

7.3.2 Approach to Reducing Greenhouse Gas Emissions

Numerous sources for reducing GHGs were identified based on observations made in the field and following a review of pertinent literature on the subject. In developing this method, we mainly observed and analysed the impact of technologies in reducing trucks' waiting time, fuel consumption and, on their GHG emissions.

Before going through the impacts of ITS on GHG reduction, an overview is provided of other GHG reduction methods and the various technologies that could be implemented in a container terminal. Three main reduction methods will be reviewed, namely:

- At-source reductions (trucks): increases fuel efficiency, engine maintenance, driving habits, etc.;

- Terminal's physical facilities (methods not using technologies): increase in the number of entry gates and reduce the number of control points inside the terminal;
- Technologies i.e. Terminal Appointment Systems, etc. (See sections 4.1 and 6.1).

Reductions at source and terminal physical facility measures are not considered in this study.

7.3.3 Approach and Greenhouse Gas Emission Factors

The emission factors used in this study incorporate the differences in engine high and low idling RPM as well as the variances during short and long idle.

High and Low Idling

High idling is defined as idling with the engine operating at high RPM. A high RPM runs when air conditioning, heaters, microwaves, TV and other on-board accessories are running. This mostly occurs during long waiting periods in cold or hot weather when truck drivers use their electrical appliances to keep the driver and sleeper compartment at adequate temperature while maintaining adequate battery voltage.

Low idling on the other hand is defined as idling with the engine operating at low RPM. Low RPM occurs when no appliance function during idling. This most often occurs in temperate climates and during short waiting.

Tests have shown that most truck engine can idle from 600 to 1200 rpm, depending on the use of on-board electrical accessories. This can have a significant impact on emissions since engine idle speed is directly related to fuel consumption. An engine that idles at 1000 rpm produces nearly twice as much as CO₂ and nearly doubled the fuel consumption rate as a truck that runs at 600 or 750 rpm.

When long idling occurs, it is almost assured that some on-board electrical accessories will be used to keep the cabin at a comfortable temperature and for other benefits such as TV, radio, etc.

The geographical location also has an influence on the overall idling habits to offset exterior temperature. Based on literature review, heating and air conditioning are usually turned-on to target cab temperature of 21°C (70°F). Therefore trucks at northern ports will likely operate their climate devices (heating) more often than in southern areas.

Emission factors were developed to follow a gradient of percentages of RPM so that a certain percentage usage could be assumed; this avoids assuming extremes of zero or full use of on-board (i.e. 600 or 1200 rpm). For example, a trucker turning on his heating rather than his TV set could see his engine at 800 rpm rather than 1200 rpm. Therefore, a certain percentage of high idling, such as 40% high idle/60% low idle was set to capture the variances in the usage of various on-board accessories. As well, when assessing a truck fleet, the percentage of high vs. low idling can also apply to the percentage of trucks from the fleet that are running at high RPM vs. at low RPM. Note that older trucks will generally be more affected by the use of electrical appliances than newer ones.

Short and Long Idling

EPA observed that relatively to the amount of fuel consumed, emissions were higher at idle than on the road by a factor of 1.5. This is due to the engine that idles with high, then low, then high RPM continuously. The engine is calibrated to follow this pattern to maintain certain regularity in the engine temperature, alternator function and cabin comfort. This is common to all vehicles. Also, drivers sometimes operate their engines at elevated engine speeds to provide more power and operate climate control devices and on-board accessories and reduce cab noise vibration and engine wear associated with low speed idling.

Based on several EPA studies, long duration idling was assumed to correspond to the truck propulsion engine when not engaged in gear for a period greater than 15 consecutive minutes. Therefore:

- Short idling occurs when vehicles move regularly such as in traffic, gate wait, etc. (< 15 min);
- Long idling occurs when vehicles stay stationary for a long period of time, such as during train crossing, waiting for a load, sleeping, etc. (> 15 min).

Emission Factors Used

The emission factors used in this study incorporate the differences in engine high and low idling RPMs as well as the variances during short and long idle. From the literature review completed (see section 4.2), those retained to calculate emissions come from EPA (US EPA, 2002) and the California Air Resource Board (CARB, 2002). However, as we have seen in the literature review, these emission factors refer to the generation of CO₂ and do not include emissions of N₂O or CH₄. To capture other GHGs, emission factors from the Environment Canada's GHG Inventory 1990-2001 (Environment Canada, 2003) for N₂O and CH₄ were included. The units of the Environment Canada emission factors are in g/L of fuel consumed. The relation between CO₂ and the other two pollutants in the Environment Canada Inventory was used to convert the CH₄ and N₂O emission factors from units of g/L to g/hr.

The emission factors used are listed in Table 7-3 for long idling and in Table 7-4 for short idling. Factors for long idling at low regime are not shown because this situation rarely happens and the emission factors were not developed for such situation (less accurate).

Table 7-3: Emission Factors Used to Estimate GHG Emissions During Long Idling

Characteristics	Emission Factors				Reference
	CO ₂ [g/L fuel]	CH ₄ [g/L fuel]	N ₂ O [g/L fuel]	CO ₂ E [g/L fuel]	
Trucks – moderate control*	2730	0.13	0.08	2757.53	Env Can, 2003
	CO ₂ [g/hr]	CH ₄ [g/hr]	N ₂ O [g/hr]	CO ₂ E [g/hr]	
100% high idle and 0% low idle	11815	0.57	0.32	11926	EPA, 2002
80% high idle and 20% low idle	10613	0.51	0.30	10717	EPA, 2002
70% high idle and 30% low idle	10012	0.48	0.29	10112	EPA, 2002
60% high idle and 40% low idle	9411	0.45	0.28	9507	EPA, 2002
50% high idle and 50% low idle	8224	0.39	0.24	8307	EPA, 2002
40% high idle and 60% low idle	7037	0.33	0.20	7106	EPA, 2002
30% high idle and 70% low idle	5850	0.27	0.16	5905	EPA, 2002

* Trucks = Heavy Duty Diesel Trucks

Table 7-4: Emission Factors Used to Estimate GHG Emissions During Short Idling

Characteristics	Emission Factors				Reference
	CO ₂ [g/L fuel]	CH ₄ [g/L fuel]	N ₂ O [g/L fuel]	CO ₂ E [g/L fuel]	
Trucks – moderate control*	2730	0.13	0.08	2757.53	Env Can, 2003
	CO ₂ [g/hr]	CH ₄ [g/hr]	N ₂ O [g/hr]	CO ₂ E [g/hr]	
100% high idle and 0% low idle	9140	0.57	0.32	9251	CARB 2003
80% high idle and 20% low idle	7493	0.51	0.30	7597	CARB 2003
70% high idle and 30% low idle	7016	0.48	0.29	7116	CARB 2003
60% high idle and 40% low idle	5846	0.45	0.28	5942	CARB 2003
50% high idle and 50% low idle	5599	0.39	0.24	5682	CARB 2003
40% high idle and 60% low idle	5353	0.33	0.20	5422	CARB 2003
30% high idle and 70% low idle	5106	0.27	0.16	5161	CARB 2003
20% high idle and 80% low idle	4859	0.21	0.12	4901	CARB 2003
0% high idle and 100% low idle	4366	0.09	0.04	4380	CARB 2003

* Trucks = Heavy Duty Diesel Trucks

The CARB emission factors correspond to the ones used to study emissions from truck idling in the US.

Analysis shows that if the Environment Canada emission factors had been used, the emissions would have been much lower. Unfortunately, Environment Canada emission factors do not incorporate variations due to long and short; and high and low idling.

Figure 7-3 and Figure 7-4 illustrate the emissions per time period per truck.

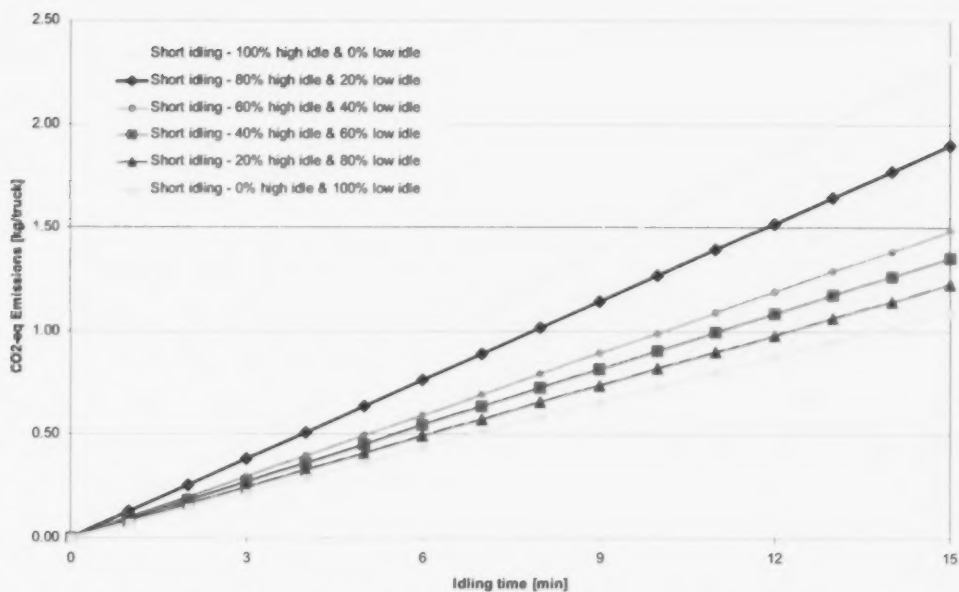


Figure 7-3: Emissions per Truck During Short Idling

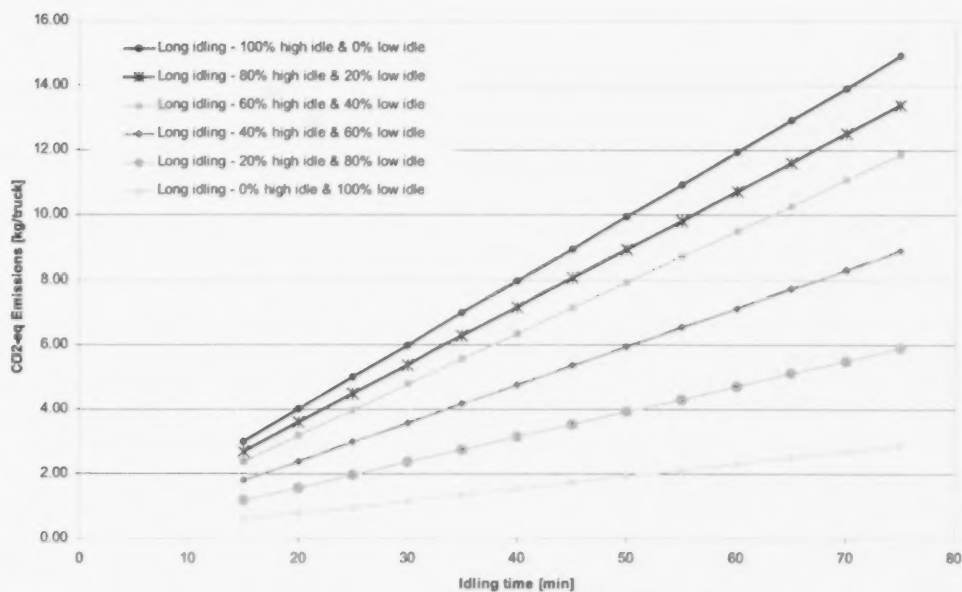


Figure 7-4: Emissions per Truck During Long Idling

The figures show emissions from idling while operating some appliances (e.g. air conditioning) are twice as high as the emissions of idling when no climate devices and on-board accessories are being used.

7.3.4 Calculation of GHG Emissions at Terminals – Current Situation

The greenhouse gas emissions calculated refer to the periods of idling that can be reduced by using technologies to increase terminal operations efficiency. These idling times were presented previously in Section 7.2. The use of appliances cannot be exactly determined since this varies throughout the year. An example of the emissions generated per truck is presented, with similar climate conditions for one specific day, (June 8th, 2005). June 8th was selected because it gives a good example of variances in climate conditions in each region, which likely engendered different behaviours in terms of drivers operating appliances in their cabin.

7.3.5 Determining Long/Short Idling

The waiting times were also examined for short or long idling conditions. Given the waiting time at the gates and the overall turn around time, the order of magnitude of other idling periods – longer or shorter than 15 minutes was determined (i.e. long or short idling). Table 7-5 presents this analysis.

Table 7-5: Choices of Emission Factors Parameters for Each Scenario

Idling Period	TRAPAC Los Angeles	STS Oakland	CAST Montreal
T ₃	0 and 10 minutes	0 and 20 minutes	5 and 10 minutes
T ₅	< 15 min	< 15 min	< 15 min
T ₇	< 15 min	< 15 min	< 15 min
T ₁₀	< 15 min	< 15 min	< 15 min
T ₁₂	< 15 min	< 15 min	< 15 min
T ₁₃	< 15 min	< 15 min	< 15 min
TOTAL	26 to 36 minutes	18 to 38 minutes	23 to 33 minutes
Set average time for the study	31 minutes	28 minutes	28 minutes

Since short idling is considered to be idling of less than 15 minutes, all idling periods occurring on this day at terminals were short idling for truck engines.

Determining High/Low Idling

The determination of high or low idling is proportionate to outside temperature as this will trigger the use of electrical appliances: heating and air conditioning, vs simple ventilation. Therefore assumptions have to be made for an overall assessment.

To compare the impacts of automation technologies on GHG emissions from truck waiting idling at terminals, emissions were calculated with similar climate conditions for all three terminals studied. i.e. a similar climate devices and on-board accessories usage was selected for all three terminals, independently of their geographical location.

However, since climatic conditions can considerably influence the amount of GHG emissions generated by trucks at different high and low RPM, the emissions from each region were calculated and compared. Table 7-6 presents the parameters chosen for high/low idling conditions for the various scenarios assessed.

**Table 7-6: Influence of Temperature on Climate Devices
and On-board Accessories**

	Temperature	Electrical Appliance Used	High/Low idling
Example for Same Temperature Throughout Regions			
TRAPAC – LA	5°C	Heating	30% High – 70% Low
STS – Oakland	5°C	Heating	30% High – 70% Low
CAST – Montreal	5°C	Heating	30% High – 70% Low
Example of June 8, 2005			
TRAPAC – LA	21°C	None	100% Low idling
STS – Oakland	14°C	Light heating	30% High – 70% Low
CAST – Montreal	+ 30°C	Full Air Conditioning	80% High – 20% Low

Current GHG Emissions

Given the calculation of waiting time for each truck processing step and using the emission factors identified in Table 7-5, GHG emissions per truck for each scenario, for June 8, 2005 climate conditions are presented in Table 7-7.

Table 7-7: GHG Emission Estimates for Each Scenario

Reason for Idling	Waiting Time [min]	Short/Long	High/Low	EF [g/hr]	Emissions [kg/truck]
Example for Same Temperature Throughout Regions					
TRAPAC – LA	31	Short	30% high – 70% low	4380	2.67
STS – Oakland	28	Short	30% high – 70% low	5161	2.41
CAST – Montreal	28	Short	30% high – 70% low	7597	2.41
Example of June 8, 2005					
TRAPAC – LA	31	Short	0% high – 100 % low	4380	2.26
STS – Oakland	28	Short	30% high – 70% low	5161	2.41
CAST – Montreal	28	Short	80% high – 20% low	7597	3.55

The calculations, assuming the same climate conditions, indicate three more waiting idling minutes increase GHG emissions of about 10%. On the other hand, the example of June 8th shows that the use of air conditioning has a considerable impact on fuel consumption and GHG emissions; switching from a 30% high to an 80% high idling increased the emissions by 30% (from 2.41 kg/truck to 3.55 kg/truck).

7.4 Impacts of Technologies on Reducing GHG Emissions

7.4.1 Impact of Technologies on Time Delays

Theoretical modelling was used to determine the impact of automation technologies and management information systems on the average waiting time idling of on-road trucks engaged in drayage at container terminals. The method permits the calculation of GHG emissions prior and after the implementation of gate automation technologies and appointments systems at two selected terminals. Both TraPac (Los Angeles) and STS (Oakland) use automation technologies in their daily operations at the gate and in the terminal. Prompted by the passage of the Lowenthal Bill, the two terminals were encouraged to reduce pollution and congestion attributed to idling trucks at the gates.

Based on observations made on site and from information provided by the terminal operators, a few interesting conclusions can be drawn and links can be made between the implementation of appointment systems, automation technology and lower GHG emissions. Considering their current day-to-day operations, the TraPac and STS terminals opted for two very different approaches to reducing waiting time at the gate. Other factors identified above (section 7.2) that may have an impact on reducing GHG emissions were not taken into account.

TraPac Terminal – Los Angeles

With operation problems at the gate and in-yard, terminal authorities decided to implement automation technologies. Table 7-8 and Table 7-9 show data on previous idling truck waiting times (prior to the implementation of systems and technologies) and current idling truck waiting times (with the implementation of systems and technologies).

Table 7-8: TraPac – Current and Past Waiting Time (truck idling)

	Past Waiting Time Average (min)	Current Waiting Time Average (min)	Δ (%)
TraPac, LA	300	31	-868

Table 7-9: TraPac – Current and Past Gate Movement

	Past Gate Movement Average (moves/day)	Current Gate Movement Average (moves/day)	Δ (%)
TraPac, LA	1650	3600	118

The average waiting time prior to the implementation of the technologies was five hours consisting of a two-hour wait outside the terminal and a three-hour wait inside the terminal. Quick action was urgently needed. Since the expansion of the terminal was not possible at the time, the use of technologies became an attractive, logical option. Disregarding the union position on automation replacing personnel, the terminal operator integrated technologies to reduce the waiting time per idling truck by 868% and increase container moves at the gate 118%. The terminal operator did not install an appointment system, deeming it unnecessary because trucks no longer had to wait at the terminal entry gate. It was more important to increase gate moves and improve the efficiency of yard operations.

STS Terminal – Oakland

STS terminal adopted a very different approach. They integrated a few automation technologies such as OCR, but primarily complied container truck drivers (or the trucking companies concerned) to use an appointment system.

Table 7-10 and Table 7-11 show data on previous waiting times (before the implementation of a mandatory appointment system) and current waiting times (with appointment system in place):

Table 7-10: STS – Current and Past Gate Movement

	Past Waiting Time Average (min)	Current Waiting Time Average (min)	Δ (%)
STS, Oak	330	28	-1079

Table 7-11: STS – Current and Past Gate Movement

	Past Gate Movement Average (moves/day)	Current Gate Movement Average (moves/day)	Δ (%)
STS, Oak	700	900	29

The integration of a mandatory appointment system decreased the average waiting time by 1079% and increased gate moves by 29%. Considering major Waiting delays with truck idling outside the terminal (5 hours), the implementation of a management system proved to be beneficial to operations.

7.4.2 GHG Emission Reductions

Through the use of state-of-the-art technologies, truck waiting times have been drastically reduced. Initially idling time could reach 6-hours, though with automation technology is has come down to less then 30 min. for the same terminals. GHG emissions in the past were therefore significantly higher than those determined for the current scenario. This section quantitatively evaluates the GHG emissions looking at past scenarios.

Determining Past Long/Short Idling

The determination of waiting time for past scenarios takes into account the following parameters:

- The waiting time at gates;
- The overall turn around time;
- The order of magnitude of other waiting periods – longer or shorter than 15 minutes;
- The attribute of idling: long or short idling.

Table 7-12 shows all idling periods that occurred in the past at STS and TraPac were long idling periods.

Table 7-12: Choices of Emission Factors Parameters for Each Scenario

Waiting Period (with truck idling)	TRAPAC Los Angeles	STS Oakland
T ₂	120 min	120 min
T ₄	> 15 min	> 15 min
T ₆	> 15 min	> 15 min
T ₈	> 15 min	> 15 min
T ₁₀	> 15 min	> 15 min
T ₁₁	> 15 min	> 15 min
TOTAL	240-300 min	240-300 min
Set average time for the study	5-6 hours	5-6 hours

Determining Past High/Low Idling

Similarly to the previous assessment for current emissions, the GHG emissions were calculated for one day showing similar climate conditions. During long idling, it is realistic to assume that truck drivers would use some on-board accessories such as TV, radio,

and even microwaves. They may also shut down their engine, especially with the increase in fuel price, which in this case would not produce GHG emissions. For comparison purposes, it was assumed that truck drivers kept their engine going; the assumptions in the usage of electrical devices (high/low rpm) during long idling are presented in Table 7-13.

Table 7-13: Assumption of the Use of On-board Accessories during Long Idling

	Temperature	Electrical Appliance Used	High/Low idling
Example for Same Temperature Throughout Regions			
TRAPAC – LA	21°C	miscellaneous	30% High – 70% Low
STS – Oakland	21°C	miscellaneous	30% High – 70% Low

Past GHG Emissions

Taking into account the short/long and high/low idling, past GHG emissions per truck for each scenario were calculated and results are presented in Table 7-14.

Table 7-14: Past GHG Emissions

Reason for Idling	Idling Time [min]	Short/Long	High/Low	GHG EF [g/hr]	GHG Emissions [kg/truck]
Example for Same Temperature Throughout Regions					
TRAPAC – LA	300	Long	30% high – 70% low	7106	35.53
STS – Oakland	330	Long	30% high – 70% low	7106	39.08

The calculations, assuming the same climate conditions, show three more waiting minutes with the truck idling increase GHG emissions of about 9%.

Comparison of Past and Current GHG Emissions

Accounting for an increase in efficiency and therefore using the number of gate moves per day, the comparison of the past and present situation, assuming all the same climate conditions and usage of electrical devices (30% high idling: 70% low idling), is presented in Table 7-15.

Table 7-15: Comparison of Past/Current GHG Emissions

	Past			Current			% Reduction
	Emissions per Truck [kg/truck]	Gate Moves /day	GHG Emissions [tons/day]	Emissions per Truck [kg/truck]	Gate Moves /day	GHG Emissions [tons/day]	
TRAPAC	35.53	1650	58.6	2.67	3600	9.6	84%
STS	39.08	700	27.4	2.41	900	2.2	92%

There were major differences in the past and current situations at both terminals assessed. TraPac, for example, reduced the emissions per truck from 35.5 kg GHG to 2.7 kg GHG and even though the number of gate moves per day more than doubled, the waiting time reduced trucks' GHG emissions by 84%. STS introduced an appointment system and reduced the truck idling emissions from 39 kg down to 2.41 kg/truck for an overall reduction – counting an increase in gate moves – by 92%.

7.5 Projected Impact of Technologies on GHG Emissions

To assess what impact state-of-the-art technologies and reservation systems have on GHG emissions, the before/after situations of the two terminals were compared. Figure 7-5 sets out the trends resulting from the use of the technologies.

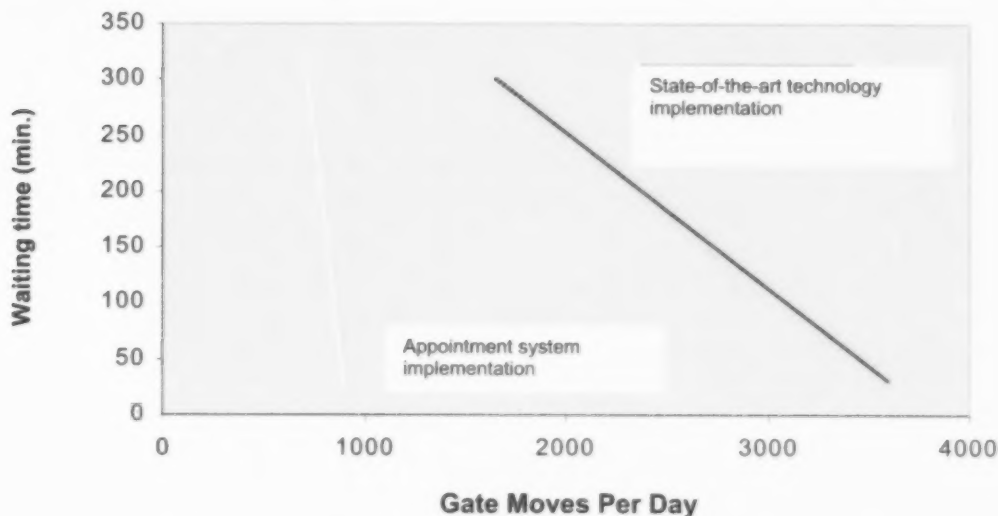


Figure 7-5: Impact of Technologies at TRAPAC and STS Terminals

Overall, TraPac gate move/waiting time ratio following the implementation of technologies indicated that truck-waiting times dropped sharply, while operational efficiency improved and the number of moves per day increased.

Since TraPac is deemed to be a reference for gate technologies, the curve resulting from the implementation of the automation technologies represents the maximum change that a terminal can achieve by implementing the technologies.

However, STS gate move/idling time ratio following the implementation of a mandatory appointment system indicates a sharp drop in idling truck waiting times at the terminal entrance, without significantly increasing operational efficiency. The number of moves per day increased only slightly.

Because STS was deemed to be a reference in operating an appointment system, the curve represents the best possible result a terminal can attain by implementing a gate appointment system

The changes at these terminals resulting from the implementation of their respective technologies and reservation systems help predict what the ultimate gains would be in terms of reducing waiting times. The comparison made in this section is therefore based on Figure 7-6, which sets out the waiting time/entry ratios resulting from the use of different technologies.

Based on the current data on waiting times and entry/exit moves the following assumptions are used to estimate and quantify the impact the technology would have on GHG emissions reduction at container terminals:

7.5.1 Include Current Co-ordinates (gate moves, idling times)

Montreal's CAST terminal currently has 1,600 gate moves and an average waiting time of 28 minutes per truck.

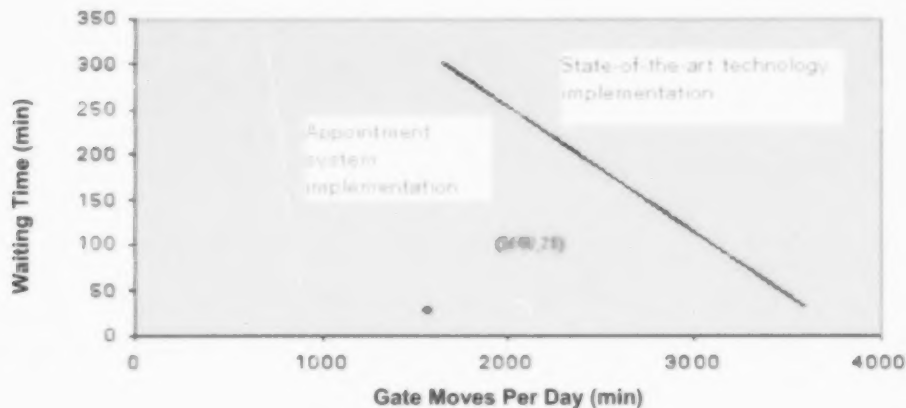


Figure 7-6: Montreal CAST – Current Positioning (Waiting Time/Gate Moves Per Day)

7.5.2 Technology Selected and Determining the New Curve

Assuming, as an example, that Montreal's CAST Terminal implements an appointment system requiring truck drivers to make appointments before arriving.

Moving the STC curve to the right as illustrated in Figure 7.7 until it intersects the CAST set point (1600 moves and 28 min waiting time) indicates the gate moves and waiting time (with truck idling) achievable with the implementation of an appointment system. The new (red) curve becomes the reference curve for the terminal.

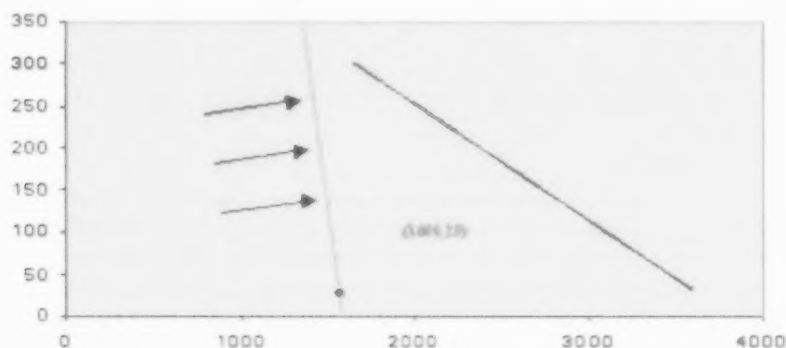


Figure 7-7: Montreal CAST – Extrapolation Curve

The equation for the "Appointment System" curve (in yellow) is:

$$Y = -1,51X + 1387 \quad (3)$$

Using the reference terminals (in this case CAST – Montreal) X, Y intersection point (1600, 28), the equation for the new reference curve can be determined:

$$Y' = -1,51X' + 2444 \quad (4)$$

Therefore, when $Y' = 0$ minutes (no waiting time):

$$X'_{\max} = 1618.5 \text{ gate moves} \quad (5)$$

The value ($X'_{\max}$) represents the maximum number of entry and exit moves at the terminal in the current context with the implementation of a mandatory appointment system.

Despite the fact that obtaining this value ($X'_{\max}$) is virtually impossible (trucks will always have to wait a little), it is not unrealistic to think that X' will range between the two values, namely 1600 and 1618 gate moves per day.

7.5.3 Determination of Waiting Time

With a range of values for the number of gate moves, it is now easy to determine possible waiting times. Table 7-16 sets out all of the possible waiting times based on the curve determined in section 7.2.

Knowing that $Y' = -1,51X' + 2444$
And that: X' ranges between 1601 and 1618

Let us calculate for instance Y' for the values of X' between 1601 and 1610. Table 7-16 sets out the range of possible values:

**Table 7-16: CAST Montreal – Extrapolation of Data
for Gate Moves and Waiting Times**

Entry/Exit Moves X'	Waiting Time Y' (min)
1601	26,49
1602	24,98
1603	23,47
1604	21,96
1605	20,45
1606	18,94
1607	17,43
1608	15,92
1609	14,41
1610	12,9

This table theoretically shows that with the implementation of an appointment system at CAST terminal in Montreal, results in an increase of only ten more gate moves per day but leads to an important reduction of about 15 minutes of waiting time per idling truck.

7.5.4 Greenhouse Gas Emissions Calculations Combined with the Strategy

The following paragraphs summarise how the GHG emission reductions can be calculated with the use of the method explained above. The approach based on anticipated waiting time reduction, is explained below along with the steps to follow.

Determine Short/Long Idling

The first step is to determine whether each waiting idling period is more or less than 15 min, less being equivalent to short idling, long being beyond 15 min. A cumulated period of time (in minutes) should be associated with each type of idling.

In the case of Montreal's CAST terminal, all waiting times were less than 15 min. therefore all were "short" idling.

Determine High/Low Idling

The second step is to determine when throughout the year and where geographically the idling occurs. This helps in making assumptions on appliances used. Until now, there is no chart available to help determine whether the use of the heater is at 20%, 30% or 40% high idling. The key is to maintain the same assumptions across scenarios to consistently compare GHG reductions.

For Montreal, given that the climatic conditions usually requires the use of heating or air conditioning – the period of time when none of these accessories are used is limited – a general ration of 80% high idling and 20% low idling was used. This assumption is somewhat conservative.

Identify and Determine Appropriate GHG Emissions per Truck

Using Figure 7-8, select appropriate chart and curve and identify the emission factors appropriate to the case study.

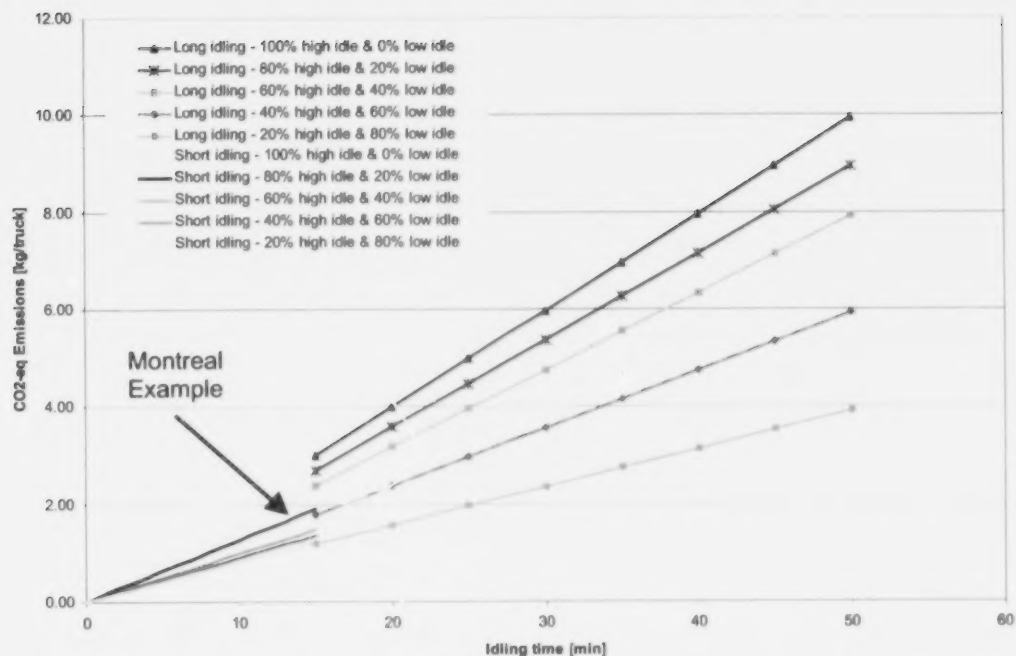


Figure 7-8: GHG Emission Factors for Long/Short and High/Low Idling

For the Montreal terminal example, i.e. short idling and 80% high idle 20% low idle, the curve of interest is the blue one (pointed by the black arrow).

Estimation of GHG Emissions Associated with Truck Idling at the Montreal's CAST Terminal

Using the number of gate moves per day, the emissions for the day at the terminal can be calculated.

Results of this process can then be summarised in a table similar to Table 7-17. This example presents a summary of calculations completed for the CAST terminal in Montreal with a scenario applied for June 2005.

Table 7-17: GHG Emission Rates and Parameters

	Waiting Time [min]	Short/Long	High /Low	EF [g/hr]	GHG Emissions [kg/truck]	Gate Moves /day	GHG Emissions [tons/day]
CAST - Mtl	28	Short	70% High - 30% Low	7116	3.32	1618	5.3

With this approach, daily GHG emissions can be calculated and summed up to generate an annual emission inventory.

Comparison of Current and Future GHG Emissions (with the implementation of an Appointment Systems at Cast Terminal)

A comparison of the current and future operational scenario is shown in Table 7-18, with the implementation of an appointment system, which results in an increase in efficiency and therefore an increase in the number of gate moves per day. We are assuming the same climate conditions and usage of electrical devices (80% high idling: 20% low idling).

Table 7-18: Comparison of Current/Future GHG Emissions

	Current			Past			% Reduction
	Emissions per Truck [kg/truck]	Gate Moves /day	GHG Emissions [tons/day]	Emissions per Truck [kg/truck]	Gate Moves /day	GHG Emissions [tons/day]	
CAST	3.55	1600	5.7	3.32	1618	5.3	8%
STS	39.08	700	27.4	2.41	900	2.2	92%

Thus if a reservation system were implemented at the CAST terminal, we could expect a GHG reduction of 8% and an increase in the number of gate moves. This would represent an annual GHG Emission reduction of about 100 tons (with 250 working days).

7.6 Canadian Applicability

7.6.1 Context

An attempt was made to transfer the lessons learned and experience of the US west coast ports to develop a strategy tailored for the Canadian context, especially for the ports of Montreal and Vancouver, to reduce the impact of GHG associated with terminal drayage activities.

The following sections will evaluate the existing legislation and programs and automated technologies related to port/terminal operations. The applicability of these options to the Canadian context is also identified.

Table 7.19 presents a description and the function of strategic components (existing programs, legislation, system applications and automated technologies) currently employed in western US ports that could be helpful in the development of a Canadian strategy.

Table 7-19: Strategic Components and Description

COMPONENT	DESCRIPTION
Environmental Program	
Port Wide Inventory	- Identification of emission reduction methods, objectives and goals - Assessment of the implications of the Kyoto Protocol on all aspects of port operations
Air Quality Monitoring	- Monitoring stations in proximity of the port area (for air quality) to determine the emission levels that are due to port activities
Legislation	
Truck Idling Reduction	- Limit truck Idling at marine terminals (e.g. Lowenthal Bill – Southern California)
System / Technology	
Port Community Information System	- System structured too facilitate end-to-end electronic information flow between trading partners, optimize the terminal/trucking interface and provide the members with a web-based low cost connectivity option relative via EDI
Terminal Operating System	- Operating systems manage (by integrating information technologies) the flow of containers through the terminal and ensure efficient cargo handling and distribution
Appointment System	- Allow truckers to schedule appointments at the terminal gate, resulting in reduced wait time for motor carriers. The terminal operator can set limits for appointments based on the capacity of their equipment in the yard. Terminals benefit from a reduction of operational costs, improved gate efficiency, accelerated throughput, and better equipment utilization.
Automation Technology	- Technology and systems such as automated equipment identification (AEI) systems, scanning system, OCR, GPS, RFID, CCTV cameras and wireless/radio data transmission
Infrastructure Improvement	
Container Terminal Expansion and CHE acquisition	- Expand terminal/port land and cargo docks allow terminal operator to increase their storage capacity and to host more ship at docks - More cargo handling equipment to increase yard productivity and reduce truck turn around time
Other Actions	
Extended Gate Hours and Warehouse Hours Coordination	- Incentive for cargo owners to move cargo at night and on weekends, to reduce truck traffic and pollution during peak daytime hours and to alleviate port congestion - Allowing truckers to load and unload their container during nights and weekends in coordination with warehouse hours
Traffic Characteristic within and outside the port	- Railway crossing (Overpass over the railway), improve access to terminal/port, Expressway for trucks and rail (Alameda Corridor)

7.6.2 Actual Status at the Ports of Montreal (POM) and Vancouver (POV)

For all the components listed above, the following table will evaluate their status, in terms of implementation (where, when and how) and responsibility (leaders) at the Port of Montreal and the Port of Vancouver.

A reference will be made if the component has already been implemented or not, or planned for the future. If no implementation has been done yet, based on the findings observed in west coast ports, a proposed time frame evaluation for implementation is indicated. The implementation schedule, the time frames will be evaluated on a short term (0-12 months), medium term (1 to 5 years) and long term (6 years and more) period.

Table 7-20: Current Status at POM and POV

COMPONENT	IMPLEMENTED	RESPONSIBILITY (Leaders)	IMPLEMENTATION (Where)	IMPLEMENTATION (When/How)
Environmental Program				
Port Wide Inventory	POM			
	No Port Authority, with three professionals in the environmental department oversees the policy's application and foster compliance among all MPA personnel and port users.	In collaboration with the City of Montreal, Environment Canada and Transport Canada	Port Area and Regional Districts	Proposed – Short Term Developing an accurate emission baseline will help to better understand where to focus emission reduction efforts to get the "biggest bang for the buck" and significant emission reductions with reasonable cost effectiveness
	POV			
	Yes. The VPA has commissioned a study to quantify air emission contributions from all port operations, and to identify opportunities for reductions. VPA is also assessing the implications of the Kyoto protocol on aspects of port operations. In concert with the Georgia Basin Marine Vessel Air Quality Work Group is to develop an accurate, locally based inventory of ship emissions in the Canadian portion of the LFV.	Transport Canada, Environment Canada, GVRD, BC Ferries and the BC Chamber of Shipping among others) to ensure the most effective use of all resources including time and fuel	Port Area and Regional Districts	On-Going The results will be used to focus emission reduction efforts over the short and longer term. The marine inventory is expected to be completed in 2006. These inventories are used: - to gain a better understanding of what and how much various sources emit - for studies to determine source impacts on air quality - to track whether emission reductions are needed or occurring
Air Quality Monitoring	POM			
	No, Air Quality Monitoring program in Place.	MPA in collaboration with the City of Montreal, Environment Canada and Transport Canada	Port Area and Regional Districts	Proposed – Short Term Emissions from ports have the potential to increase due to growth in response to increasing demand for import and export of goods. This means more cargo, ships, trucks and trains will go through the port each year to satisfy the demand.

COMPONENT	IMPLEMENTED	RESPONSIBILITY (Leaders)	IMPLEMENTATION (Where)	IMPLEMENTATION (When/How)
	POV			
	Yes, Under the Greater Vancouver Regional District (GVRD). The GVRD releases annual reports summarizing current and historic air quality by pollutant and station for that year and since monitoring began covering both their district and the FVRD. These summaries include a comparison of air quality to federal, provincial (BC) and regional air quality objectives and standards. An overview of federal and provincial objectives and standards is available through the MOE.	Environment Canada, BC Ministry of Environment (MOE), the Greater Vancouver Regional District (GVRD) and the Fraser Valley Regional District (FVRD) work together to monitor ambient air quality throughout the Canadian portion of the Lower Fraser Valley airshed region.	Port Area and Regional Districts collaborating with other ports, the marine industry and with government agencies to promote efficiency and the implementation of technologies to reduce air emissions.	On-Going Number of air emission reduction projects already underway and planned for the future. - Hydrogen Injection Pilot program (2006), using hydrogen fuel injection (HFI) technology. - CombustAll Catalyst Tests have been completed in 2005 using CombustAll, developed in Canada. CombustAll is a chemical catalyst which, when added to diesel, increases the combustion efficiency of the engine and reduces fuel consumption. Emissions of criteria air contaminants and greenhouse gases are reduced as a result. - Shore Power In the process of assessing the feasibility of developing shore power capabilities for cruise ships, so that when ships are at dock they can plug into the grid for power and shut down their diesel powered engines. Long Term - Supply Chain Optimization Investigating options for improving supply chain efficiency, thereby reducing emissions from trucks, trains and ships. Improvements include continuous, real-time monitoring, truck anti-idling programs, reservation systems, and extended terminal hours among others.

COMPONENT	IMPLEMENTED	RESPONSIBILITY (Leaders)	IMPLEMENTATION (Where)	IMPLEMENTATION (When/How)
Legislation				
Truck Idling Reduction	No. Specific mandatory truck idling reduction program at marine terminals – Only a "Idle – Free Quiet Zone" Campaign run by the Natural Resources Canada's Office of Energy Efficiency (OEE)	Implementation by Government of Canada Law Enforcement by Port Authority	All marine ports and terminals (Canada)	Proposed – Short term Regulation can act as a catalyst to make terminal yard management more efficient and reduce GHG
Technology/System Implementation				
Port Community Information System	POM			
	No. Extranet system project was follow-on to an earlier project that studied the port's communication needs and recommended an extranet system. Electronic data interchange (EDI) is used throughout the Montreal port system. At least 70 per cent of containership manifests are transmitted electronically by shipping lines to the Montreal Port Authority and the Canada Customs and Revenue Agency	Port Authority	Port Community and stakeholders	Proposed – Short Term Recommended the implementation of the pilot (Extranet) phase be executed with a limited group of selected participants of the port community
	POV			
	Yes. A Pacific Gateway Portal (PGP) web-based interface (community information system) to users for real-time cargo information, vessel activity, container status as well as driver validation (CAM).	Port Authority	Port Community and stakeholders	On-Going

COMPONENT	IMPLEMENTED	RESPONSIBILITY (Leaders)	IMPLEMENTATION (Where)	IMPLEMENTATION (When/How)
Terminal Operating Systems (TOS)	POM			
	Yes. CAST terminals are using a fully integrated yard and vessel management system (NAVIS). As part of the integrated system, GPS installed on cargo handling equipment used for equipment localization. Real time monitoring is supported by RFID using handheld and VMTs used in all terminal operations. CAST and Racine are one of the most secure container complexes in North America. They are completely fenced, illuminated and have a high-resolution video surveillance system.	Terminals and Shipping Lines (owner of container)	Terminals	On-going
	POV			
	Yes Port is committed to fast turnaround times through training and technology improvements that speed the flow of intermodal cargo information and optimize the utilization of facilities and equipment to continuously improve productivity. All South shore accesses at the Port of Vancouver are controlled by a vehicle access control system (VACS) including a card access management (CAM) and changes according to the security level. Container terminals are using mostly in-house yard management systems.	Terminals	At the terminal	On-going TSI in Deltaport had planned to switch to NAVIS by the end of 2005. Future steps will be to integrate all rail activities, truck reservation system (actually owned and managed by the terminals) and to transfer information via EDI to the VACS system.

COMPONENT	IMPLEMENTED	RESPONSIBILITY (Leaders)	IMPLEMENTATION (Where)	IMPLEMENTATION (When/How)
Appointment Systems	POM			
	No, CAST terminal has no appointment system in place. Drivers proceed manually for the validation/ verification of container vehicle and driver.	Terminals	At the terminal	Proposed – Medium term POM cites that currently there is no congestion or trucks waiting at the gate.
	POV			
	Yes, POV has been successful, since 1999, in reducing truck emissions with its container reservation system. Wait times for trucks entering terminals to load goods have been reduced from two hours to an average of 20 minutes, severely cutting back the amount of time spent idling. Terminals at the Port of Vancouver currently employ truck reservation systems. TSI implemented a mandatory truck reservation system at both Deltaport and Vanterm terminals in January 2006.	VPA and Terminals Port and terminal cargo information systems have also been initiated at POV. A voluntary trucker reservation system is currently part of the terminal cargo information system. The port is also considering mandatory reservation for truckers in the future.	At the terminal	On-going Upgrades to these systems are underway and once completed, wait times are expected to be significantly reduced. The reservation system allocates a time for each truck to come to the terminal to load or unload, thus preventing congestion at certain times that can lead to long truck waits and idling. The port will collect baseline information prior to completion of system upgrades to compare with post-implementation data that will be used to quantify reduction in wait times and fuel consumption, as well as reductions in emission of CACs and GHGs.

COMPONENT	IMPLEMENTED	RESPONSIBILITY (Leaders)	IMPLEMENTATION (Where)	IMPLEMENTATION (When/How)
Automation Technologies	POM			
	Yes, CAST terminal operates CCTV cameras, but no hardware like OCR or RFID (tags).	Terminals	Terminals OCR for equipment identification and security enhancement at the gate and in yard. RFID for equipment identification and positioning and for container security.	Proposed – Short term CAST is actually conducting studies for the implementation of OCR technologies. Implementation is expected by 2007. The existing yard and vessel management system can benefit from data from OCR and RFID to reduce truck turn around time, truck idling and enhance terminal productivity.
	POV			
	Yes, integrated TOS are using infrared RFID tags allowing trucks which respond to the classification system to be automatically identified at the terminal/port gates and real-time RF data collection for efficient dispatch. A new control room to gather all images from CCTV cameras installed at the terminal access points	Terminals	Terminals Automated truck gates with OCR for container/equipment. Identification and security enhancement at the gate and in yard. RTG and gantry cranes fitted with OCR technology.	Proposed – Short term Considering the existing yard and vessel management system can benefit from data from OCR and RFID to reduce truck turn around time, truck idling and enhance terminal productivity.

COMPONENT	IMPLEMENTED	RESPONSIBILITY (Leaders)	IMPLEMENTATION (Where)	IMPLEMENTATION (When/How)
Infrastructure Improvement				
Container Terminal Expansion (Capacity)	POM			
	The MPA favors maximum use of port facilities on the Island of Montreal, and will acquire any available land that can be economically developed adjacent to active handling zones on the Island of Montreal. It will also develop Contrecoeur in order to ensure the Port of Montreal's long-term growth. CAST is planning to expand its terminal area by acquiring new land on the Island of Montreal.	MPA and terminals	Terminals	On-going Negotiations still going on.
	POV			
	West coast of North America is expected to triple in the next 20 years. In order to meet future requirements, the VPA has examined options to increase the port's container terminal capacity. In August 2002, the VPA announced the beginning of the process and it is looking at a three-pronged approach to increasing container capacity at the Port of Vancouver: - Efficiencies at existing terminals; - Expansion at existing terminals; - Building new facilities.	VPA and Terminals	At the terminal There is growing need for terminals at the port to handle larger ships. As growth continues, more containers will come through the port on fewer larger ships, vs. many smaller ships (ie. fewer ships per unit of cargo). Larger ships are newer and will have more efficient engines than smaller, older vessels. Currently, all container terminals at the port have the capacity to handle these larger ships.	On-going

COMPONENT	IMPLEMENTED	RESPONSIBILITY (Leaders)	IMPLEMENTATION (Where)	IMPLEMENTATION (When/How)
Other Actions				
Extended Gate Hours and Warehouse Coordination	POM			
	No Program But CAST – Racine Terminal offers extended gate hours when needed to evacuate the yard for arrival of new ships.	Terminals and trucking companies in collaboration with customers (warehouse)	At the terminal	Proposed – Medium term MPA states that no trucks are actually waiting at the gate and no congestion in the port area. Proposes no extended gate hour program or required warehouse coordination.
	POV			
	No The terminal operators are planning to extend container terminal hours. Currently, gates are only opened if required volumes are sufficient. Carriers without prior notification and reservation will not be serviced. POV is evaluating mandatory systems for the future.	Terminals and trucking companies in collaboration with customers (warehouse)	At the terminal	Proposed – Short Term Planning to extend container terminal hours beginning January 2006 in order to reduce truck wait times, and to reduce congestion on local and regional roadways during peak traffic periods. Benefits include shorter wait times, less traffic, more efficient use of fuel and reduced emissions of CACs and GHGs.

COMPONENT	IMPLEMENTED	RESPONSIBILITY (Leaders)	IMPLEMENTATION (Where)	IMPLEMENTATION (When/How)
Traffic Characteristics	POM			
	MPA is responsible for the roadway and the railway within the port area.	MPA, Terminals, City of Montreal and MTQ	Port sector and access – railroad crossing. The main access, in the port, to Termont Terminal is blocked daily by the train transiting to CAST and Racine Terminal (on demand) forcing trucks to wait in line. Port access: increase the number of access points to the container terminal.	Proposed – Medium term – Termont Terminal plans to evaluate with MPA a way to relocate the rail track or find a solution to eliminate conflicts by, for example, building an overpass over the railroad to allow trucks to access the terminal. CAST terminal requires all trucks to go through the same access point to enter or exit the terminal; thereby reducing the capacity on either side. Is building new access from the port to the municipal street to separate inbound and outbound traffic. This solution should increase the capacity of each access point and increase the throughput at the same time.
Union Negotiations	POM and POV Terminals are responsible for union negotiations.	Terminals and Union Stakeholders	At terminals where union workers are interfacing with system and technology.	Proposed – Short to long term On-going negotiation process to demonstrate to union members legitimacy and necessity for implementing system and technology to increase in-yard productivity, reduce truck turn around time and GHG emissions.

7.6.3 Canadian Applicability

Based on the different contexts and findings at the ports of Montreal and Vancouver, we can identify and propose, for the other ports in Canada, a program which highlights the principal actions (and identified leaders) necessary for achieving the goals of increasing container truck fluidity at marine terminal gates in order to reduce gate idling time and GHG emissions.

In order of implementation:

Short Term

1) Elaboration of a Port Wide-Inventory Program (Air Quality)

Identified Leader: Governments, Port Authority and Environment Canada

- Bring together all harbour and environmental stakeholders;
- Identify opportunities for reductions and assess the implications of the Kyoto protocol on aspects of port operations (inventory of ship, truck and marine equipment emissions);
- Identify emission reduction methods (monitoring, incentives), objectives and goals;
- Develop an accurate data baseline;
- Quantify air emission contributions from all port operations;

These actions will help to better understand where to focus emission reduction efforts to get the "biggest bang for the buck", achieving significant emission reductions with reasonable cost efficiency.

The results will be used to focus emission reduction efforts over the short and longer terms. These inventories are used:

- To gain a better understanding of what and how much various sources emit;
- For studies to determine source impacts on air quality;
- To track whether emission reductions are needed or occurring.

2) Truck Idling Reduction Regulation

Identified Leader: Governments, Port Authority, Terminal Operators and Trucking Stakeholders

Congestion at the ports is a pressing issue for effective goods movement. The combined burden of inefficiencies due to traffic congestion and pollution from trucks idling at ports should lead to the passage of a truck idling regulation.

- Bring together all marine, environmental and trucking stakeholders;
- Establishment of a clear regulation for limiting truck idling within the port area especially at marine terminals (e.g. Lowenthal Bill in southern California);

- Deployment of a well organised law enforcement team in the field.

Should be implemented as a catalyst to optimize terminal yard management and a way to reduce GHG.

3) Optimize Terminal Operations

Identified Leader: Terminal Operators

Terminal operations using integrated management systems and technologies can ensure that containers are properly dispatched (in the yard, on vessel, on rail and on truck) and cargo movements handled efficiently. Terminals benefit from reduced operational costs from improved gate efficiency, accelerated throughput, and better equipment utilization, and this also results in reduced waiting time for truckers.

- Implementation of terminal operation systems and technology
 - i. Yard and vessel management system (NAVIS, COSMOS, Embarcadero);
 - ii. Automated identification system for equipment (container, truck plate and chassis) identification and security enhancement at the gate and in-yard (OCR and bar-code reader). RF using handheld and VMTs can support real time data acquisition in all terminal operations;
 - iii. Positioning system – GPS can be installed on cargo handling equipment for equipment positioning. RFID technology can also be part of the integrated as a tag installed on different equipment like container or truck plate for identification;
 - iv. Gate/yard monitoring system – CCTV cameras and wireless/radio data transmission equipment related to a control centre to gather all images (from the gate and yard) and voice transmission (from clerks and in-yard operators).

4) Implementation of a Port Community Information System

Identified Leaders: Governments, Port Authority, Terminal Operators, Trucking Industry and Trading Partners

System to be structured to facilitate end-to-end electronic information flow between trading partners, improve the terminal/trucking interface and provide members with a web-based low cost connectivity option via EDI. Enable port users to:

- Post and receive information on the location and status of intermodal freight shipments including export bookings, customs manifests, receipts and invoices, gate moves, carrier insurance/credit status, delivery confirmation;
- Provide truck and trucker identification;
- Information on travel conditions along access roads and major freight routes serving the port/terminal.

In addition, such a system would enhance the visibility of cargo and port activity for shippers and members of the supply chain as well as enhance gateway security, reducing time delays caused by incomplete cargo documentation, delayed release of cargo, bypassing traffic congestion and reduce congestion and pollution. A centralized

database and technologies can offer tools and information to the port community to improve inter-organisation information flow and hence service and business performance.

Medium Term

- 5) Optimize Terminal Operations – Terminal appointment system (Embarcadero and eModal) and extended gate hours (e.g.: Pier Pass)

Identified Leaders: Terminal Operators and Trucking Industry

In response to the implementation of truck idling regulation, a reservation system and an extended gate hours program (Pier Pass) could be implemented at terminals to minimize truck waiting times.

But, congestion and yard efficiency should always be major issues for implementing such systems and programs conjointly

Depending on the traffic situation around the terminal (or port) and on the operational aspects of yard management (capacity of drayage), the terminal operators should start with:

- Implementation of a mandatory reservation system with a flexible operations structure allowing truckers (or their company) to reserve either by Internet, phone, or by sending a fax up to five minutes prior to truck arrival at the gate. This system should be open-ended, taking into account the needs of the trucking community (language barriers, etc.) and their own operational reality. The customer service benefits to the trucking industry include advance booking, priority/preferred access, and elimination of trucking queues, fewer 'trouble window' transactions and faster turnaround time. From the terminal perspective the use of an appointment system translates into operational improvements such as reducing yard congestion and pre-planning of mounted import containers on chassis to reduce cargo-handling time.

Trucking companies could also use the reservation system to pre-approve (real-time) their drivers for container pick-up and drop-off. So, when truck drivers arrive at a terminal, they spend less time waiting at the gate. Terminals also can be assured they are delivering containers to the trucking company's designated drivers.

If terminals, after implementing a reservation system, again experience congestion, they should evaluate the use of extended gate hours and/or coordination of warehouse hours:

- The program should be an incentive for cargo owners to move cargo at night and on weekends, to reduce truck traffic and pollution during peak daytime traffic hours and to alleviate port congestion. This requires all terminals to coordinate their gate hours so they are open during nights and weekends, allowing trucks to pick up and off-load their containers.

These five actions, based on implemented projects, are given as guidance for Canadian port stakeholders (especially for terminal operators) for reducing truck idling at terminal gates, increase terminal operation efficiency and the most importantly reducing GHG emissions in the port community.

8 CONCLUSION

The overall objective of this study was to assess the impacts of implementing appointment systems and other programs to improve cargo velocity at ports and terminals in order to reduce congestion, delays and GHG emissions. The report examines a strategy to improve port/terminal operations efficiency and reduce emissions at Canadian ports. The study also reports on the merits of a gate reservation/appointment system, which can be effectively applied to container terminals to reduce emissions and improve productivity.

A comprehensive Canadian strategy should include policies including legislation and regulation, air quality mitigation programs, infrastructure improvements as well as the introduction of better port information systems and new technology leading to more efficient operations. In the Canadian context there is no equivalent to the Lowenthal Bill, which requires terminals to ensure trucks limit idling to 30 minutes or face fines. However, the Port of Vancouver has implemented a mandatory reservation system for truckers.

For any of these initiatives to be successful, the close cooperation of all stakeholders, including local and regional authorities is necessary. Terminal appointment systems and extended gate hours are essential for balancing capacity at terminals as well as reducing congestion on roads networks by spreading the truck traffic over a longer period.

The quantitative comparison in the previous section demonstrates the real reduction in GHG emissions due to the implementation of gate reservation systems and advanced gate technologies. The key factor was the reduction in waiting time.

The following sections address some of the key policies, programs and technologies implemented by ports and terminals under discussion in this report. A number of initiatives implemented in both US and Canadian west coast ports to reduce congestion, decrease emissions and increase productivity revolve around the following implementations:

Regulation and Legislation

The Lowenthal Bill was enacted primarily on environmental considerations related to extended truck idling at terminals. In some cases the Bill acted as a catalyst leading to increased automation and terminal operation efficiency. Efficiency and productivity were the key factors in the decision of making the appointment system work. Automated technology such as Optical Character Recognition and terminal expansion appear to be part of the reason why truck idling and queuing were reduced at terminals. The choice of the technology depends on the terminal operation, corporate culture, location and capacity. Issues are still outstanding for the operation of the appointment system but the situation is better and truckers do not want to "go back to the past".

Terminal Appointment System

Terminal Appointment Systems were implemented in California to address the requirements of the Lowenthal Bill. The Bill is aimed at reducing vehicle diesel emissions by fining port container terminal operators if truckers have to wait in line outside a

container terminal for more than thirty minutes to gain entrance to pick up or deliver containers.

The implementation of an appointment system had some effect in reducing truck idling/queuing at west coast terminals, although the impacts of its usage will vary depending on the factors that are producing congestion. STS, Oakland and TSI, Deltaport provided positive feedback on the effective use of an appointment system.

In southern Californian terminals (LA/LB) appointments form a small percentage of all gate moves and although there was some reduction in queue time, there is no evidence that it was a result of appointments. In several terminals no significant idling or queuing reduction occurred because most truck drivers were not using the appointment systems. For the most part, queuing was moved from outside to inside terminal gates.

There are many reasons why this occurred; including the difficulty truck drivers have in setting appointments 24 hours in advance. It is almost impossible for them to determine their arrival time at a terminal due to other transactions scheduled for that day. The driver must factor in travelling time on congested public roads, transaction time at other terminals (13 terminals in the region) and the number of trips planned for the day. Consequently, drayage firms set up several appointments to pick up the same container. This results in a significant percentage of cancelled or missed appointments. A common observation is that truck drivers fail to show up for their appointment, creating "opened" or "unoccupied" gates, while there is a queue of trucks waiting in the "non-appointment" traffic lane.

Appointment systems should be implemented with care due to the challenges faced by both drayage operators and terminals. Reported benefits of such systems include reduced wait times, improved gate efficiency, accelerated throughput and better equipment utilization. The successful implementation of systems at several North American container terminals (including Vancouver) shows that an appointment system must be flexible to be successful. The system should be able to:

- 1 Handle cancellations;
- 2 Re-assign reserved time that has been cancelled (or for which the truck does not show up);
- 3 Allow appointments to be set during the day (rather than only 24 hrs ahead)
- 4 Refuse or discourage double/triple reservations for the same container;
- 5 Introduction of fines for missed reservations;
- 6 Allow a one hour window for trucks to show up;
- 7 Appointment systems based on container appointment (vs. truck appointment);
- 8 Allow telephone reservation.

Extended Gate Hours

Terminal operators in California created Pier PASS, a not for-profit company, in order to reduce congestion and improve air quality in and around the ports of LB and LA. The original Lowenthal Bill legislation, while not apparently bringing about the change in

behaviour it originally intended on the part of both truckers and terminal operators, may have given the marine terminal operators a tool to use in organizing off-peak hours better.

The PierPass system provides for night operation which relieves the pressure on highways during the peak daytime periods. The PierPass system complemented the use of truck appointments and was instrumental in reducing both congestion and pollution. Extended Gate hours and coordination of gate hours with neighbouring terminals were very effective in reducing the number of trips and wait time.

The Port of Vancouver and its major container terminal operators have also agreed to extend gate hours to help alleviate traffic congestion. Proposed initiatives include extended gate hours (24/7 operation), a mandatory reservation system and coordinated dispatch throughout the gateway. The program is intended to improve terminal operations efficiency by increasing truck moves/day. "Extending gate hours will not only increase capacity, it will help alleviate congestion at the terminals...and speed up transaction times," according to Gordon Houston of VPA².

Both Montreal and Vancouver have extended the terminal operation hours beyond 8 a.m. to 5 p.m. in an attempt to avoid truck line-ups at the gate. This is driven more by motor carriers to increase their turnaround time than by a desire to reduce vehicle emissions. A recent report commissioned by VPA indicated that the implementation of extended gate hours at the terminal has emerged as the single most effective method for reducing delays for trucks accessing the terminals.

Innovative Technology, Automation and Equipment

The implementation of advanced technologies and information systems to increase operational efficiencies is another approach to reduce congestion and pollution. Most terminals have implemented gate automation to increase productivity of terminal operations and reduce congestion. Gate automation through OCR and terminal expansion have contributed significantly to reducing truck idling and queuing. OCR is also being installed on gantry cranes to identify boxes. TOS and gate automation technologies systems have shown an increase in operational efficiency by reducing idling times. These advanced technology applications may include integrated data management systems, smart card data transfer systems, Internet-based real-time notification systems, and wireless data transfer.

Terminal operational efficiencies could also be improved through gate segregation, e.g. reserving some gates for empty containers while others process only trucks with pre-clearance/reservations. Other terminals manage truck traffic by scheduling container pick up after the expiry of the container storage (5 days free storage allowed before demurrage is paid); thus all trucks come to pick up their container on the same day (LA/LB).

In particular, the speed and efficiency of container handling equipment and accurate positioning of containers can increase the throughput of the terminal. The speed and productivity of ship-to-shore quay cranes is the single most important factor in the efficiency of a container terminal. The handling of containers within a terminal is typically

² Canadian Sailings, October 2005

accomplished either with a fleet of dedicated container movement vehicles or with straddle carriers such as RTG or RMG.

The initial investment may seem high; however, some terminals having gone through the process, experience a payback time of less than two years. In fact, the document entitled "California Marine Transportation System Infrastructure" (March 11th, 2003) states: "Without adequate funding for marine transportation systems projects, economic growth, environmental quality and homeland security are threatened."

Virtual Container Yard and Infrastructure improvements

Virtual Container Yard is essentially a means to match shippers with containers via the Internet to avoid empty container moves to and from the terminal. A web-based information system with inventory of empty containers allows suppliers and shippers to access containers at convenient storage locations outside the terminal. This avoids unnecessary trips to the terminal and results in savings to both terminals and truckers. The scheme essentially reduces the number of truck trips and increases drayage productivity.

Traffic congestion on public roads led to the implementation of the Pier Pass program incorporating extended hours for terminals. In addition, having dedicated truck access roads when travelling between terminals can reduce traffic congestion on public roads. Port authorities are also seeking to rationalize the road network serving terminals by eliminating level rail crossings and by building overpasses over rail tracks. Another approach to get trucks off the highways during peak hours is the use of shuttle trains to move intermodal containers from ports to rail terminals during the night (Oakland).

Vehicle Emission Reduction

The issues of old trucks, low truck maintenance, and salaries based on amount of container movements, etc., encountered in California (LA/LB and Oakland), could be tackled with mitigation programs such as:

- Retrofitting trucks with DOCs or comparable exhaust controls;
- Replacing older trucks with newer (but not necessarily new) trucks;
- Replacing old engines with newer engines;
- Truck inspection.

Institutional Issues

A number of institutional factors contribute to delays, congestion and increase in emissions at ports and terminals. There is a predominance of owner-operators engaged in drayage at the Port of Vancouver who are paid on a per-trip basis, in contrast to hired drivers employed by trucking companies who are paid on an hourly basis. This anomaly has contributed to the labour disputes at the Port of Vancouver and led indirectly to the implementation of an appointment system in an effort to reduce wait time at the gate and increase the number of trips per day. The recent dispute in Vancouver resulted in the forced compliance of the trucking companies employing the owner-operators through a licensing mechanism.

In southern California there exists a shortage of truck drivers. This enables a large pool of immigrant labour to fill the need. Consequently, language barriers exist between truckers and terminal clerks and terminals have provided bilingual signs at gate entrances.

9 RECOMMENDATIONS

North American terminals face significant limitations in their capacities to handle increased container volume. This places increased strain on the container drayage sector to remain productive and respect local and regional air quality concerns. Given the magnitude of the flow of goods, port authorities must improve infrastructure and implement technologies to keep pace with the steadily increasing growth of containerized freight.

The following recommendations focus on suggestions which would lead to improvements to the trucker registration/appointment system and other strategies to reduce GHG emissions at ports and terminals.

- Appointment systems work well if efforts are made to explain the benefits to all stakeholders. There has to be a *buy-in* from the trucking community. The essence of a well-functioning appointment system is the inherent flexibility for managing trucking companies' and drivers' requirements. Communication and the understanding of each party's needs are essential. A prime consideration is the integration of an appointment system into the terminal operating system such that information on container status, location, and operational schedule is transparent. Thus, when a trucker books an appointment to pick up a container, the TOS has to validate the request and make provisions for pick up or delivery.
- The implementation of appointment systems and technologies is a means to increase terminal productivity, although some terminal operators may face resistance from unions. For example, appointment systems and gate automation not only reduce delays and congestion associated with manual data entry, they also reduce labour requirements. Communication and understanding of each party's needs are essential. Terminals have found that investment in state-of-the-art technologies proves to be economically viable with a short payback periods.
- Economic growth is a fact: marine terminals will continue to handle an increasing volume of containers. Without doubt, new technologies are likely to be needed shortly to improve efficiency since the available land for terminal expansion is limited. Implementing technology early in the life cycle of a terminal rather than at a later stage to increase productivity avoids conflicts amongst all parties.
- Several other factors other than those analysed in this study play important roles in reducing truck idling at terminals. It is necessary to thoroughly investigate factors such as railroad level crossing and public highway congestion, empty container exchange, etc., and elaborate a variety of approaches to resolve these issues. Extended gate hours are a key to relieve traffic congestion. The list of approaches should also address external programs such as extended hours (i.e. Pier Pass) prior to the selection of specific technologies and methodologies. The program has been effective in improving terminal operations efficiency and increasing truck moves/day.
- Policies and programs are needed to reduce emissions and address air quality concerns. Port stakeholders such as terminal operators, shippers and carriers should be encouraged to participate in reducing fuel consumption and vehicle emissions by:

Port Authorities – Develop an emission inventory of the port and terminal operations in order to highlight and assess the major sources of air pollution; establish a baseline emission level; prioritize emission mitigation based on the

magnitude of the sources of emissions; elaborate a list mitigation measures; and establish the feasibility and potential achievements of the mitigation measures.

Port Authorities /Terminal Operators and Carriers – Apply and develop tools and studies such as the methodology outlined in this study for assessing appointment systems or other integrated technologies which can be applied to reduce GHG; develop a cost/benefit analysis; target potential funding or paybacks; implement the systems; monitor emissions reductions and/or ambient air quality changes.

10 REFERENCES

- Argonne National Laboratory, "Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks", June 2000.
- Brodrick et al, "Potential Benefits of Utilizing Fuel Cell Power Units in Lieu of Heavy-Duty Truck Engine Idling", University of California Davis, Institute of Transportation Studies, 2001.
- California Air Resources Board, "Overview of the EMFAC Emissions Inventory Model", Emissions Inventories series, Volume 1, Issue 6, July 2002; website: <http://www.arb.ca.gov/msei/on-road/briefs/emfac7.pdf>
- California Air Resources Board, "Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant", Appendix III, Part A, Exposure Assessment, California Air Resources Board, CA, 1998.
- California Air Resource Board, "Public Hearing to Consider the Adoption of Heavy-Duty Vehicle Idling Emission Reduction Requirements" CEPA, 5th of December 2003.
- California Marine and Intermodal Transportation System Advisory Council, Northern California Marine Transportation System Advisory Council, Southern California Marine Transportation System Advisory Council, 2003, "California Marine Transportation System Infrastructure Needs", March 11.
- IMO, Regulations for the Prevention of Air Pollution from Ships, Annex VI of MARPOL 73/78; website: <http://www.imo.org/Environment/greenhouse#greenhouse>.
- Levelton Consultants Ltd., "Backcast and Forecast of Year 2000 Lower Fraser Valley Marine Vessel Emissions", Greater Vancouver Regional District – Policy and Planning Department, 402-0976, June 2003a.
- Levelton Consultants Ltd., "Forecast and Backcast of the 2000 Emission Inventory for the Lower Fraser Valley Airshed 1985 – 2025", Greater Vancouver Regional District – Policy and Planning Department, Fraser Valley Regional District, July 2003b.
- Lowenthal S., "Air pollution: diesel emissions", Bill Number: AB 2650, Chapter 1129, California Port Community Air Quality Program: Bay Area Air Quality Management District and South Coast Air Quality Management District, February 22, 2002.
- Lowenthal S., "An act to amend Section 40720 of the Health and Safety Code, relating to air resources", Bull Number SB761, February 22 2005.
- Ministère du développement durable, de l'environnement et des parcs du Québec, "Document explicatif portant sur le Projet de Règlement sur les normes environnementales applicables aux véhicules lourds", Programme d'inspection et d'entretien des véhicules automobiles lourds (PIEVAL), website : <http://www.mddep.gouv.qc.ca/air/pieval/doc-exp.htm#type>.
- Ministère du développement durable, de l'environnement et des parcs du Québec, "Type de programme pour l'inspection des véhicules lourds dans les provinces ou États limitrophes au Québec", Programme d'inspection des émissions véhicules automobiles lourds (PIEVAL), website : <http://www.mddep.gouv.qc.ca/air/pieval/doc-exp.htm#type>.

- Natural Resources Canada's Office of Energy Efficiency (OEE), website: <http://oee.nrcan.gc.ca/corporate/programs.cfm?attr=16>
- Singh R. B., Sloan J.J., "Development and Application of a Micro Scale Emission Factor Model (MicroFac) for Mobile Source Emissions", 14th Annual Emission Inventory Conference, Las Vegas, NV, April 2005.
- (S&T)2 Consultants Inc., "GHGenius, A Model for Lifecycle Assessment of Transportation Fuel", website: <http://www.oee.nrcan.gc.ca/transportation/tools/greenhouse-gas-info.cfm?attr=20>
- Starcrest Consulting Group, LLC, "2002 Baseline Emissions Inventory –cargo handling equipment, Rail Locomotives & Heavy-Duty Vehicles", March 2004.
- Starcrest Consulting Group, "Port of Long Beach 2002 Baseline Emissions Inventory", Port of Long Beach, March 2004.
- Starcrest Consulting Group, LLC, "Port-Wide Baseline Air Emissions Inventory –Final Draft", June 2004b.
- United States Environmental Protection Agency, email conversation between Levelton Consultants and EPA personnel, June 2005.
- United States Environmental Protection Agency, "Study of Exhaust Emissions from Idling Heavy-Duty Diesel Trucks and Commercially Available Idle-Reducing Devices", Air and Radiation, EPA420-02-025, October 2002.
- United States Environmental Protection Agency, "User's Guide to MOBILE6.1 and MOBILE6.2: Mobile Source Emission Factor Model", Assessment and Standards Division, Office of Transportation and Air Quality, EPA420-R-02-028, October 2002.
- United States Environmental Protection Agency, "Emission Facts – Idling Vehicle Emissions", Air and Radiation, Office of Mobile Sources, EPA420-F-98-014, April 1998.
- United States Environmental Protection Agency, "Guidance for Quantifying and Using Long Duration Truck Idling Emission Reductions in State Implementation Plans and Transportation Conformity", Office of Transportation and Air Quality, EPA420-B-04-001, January 2004.
- United States Environmental Protection Agency Office of Transportation and Air Quality, "Introducing MOVES2004, the initial release of EPA's new generation mobile source emission model", John Koupal, Mitch Cumberworth, Megan Beardsley, Assessment and Standards Division, 2004.
- Ville de Montréal, "Projet de règlement sur la nuisance causée par un véhicule moteur", Projet Texte Règlement, 20051123CE, 2005.

11 BIBLIOGRAPHY

- Administration portuaire de Montréal, « Rapport Annuel 2003 », April 2004.
- American Association of Port Authorities, website:
<http://www.aapadirectory.com/cgi-bin/showsustprofile.cgi?id=3949>
- BCE Emergis, "Port of Montreal Extranet Design, Summary Report" for the Transportation Development Center of Transport Canada, by, December 2000. TP 13731.
- Bryant R., "Ship Source Air Emissions", Vancouver Port Authority, Environmental Managers Meeting, Vancouver, June 9 2004.
- Cadle S.H., Croes B.E, Minassian F., Natarajan, Tierney E.J., Lawson D.R., "Real-World Vehicle Emissions: A Summary of the Thirteenth Coordinating Research Council On-Road Vehicle Emissions Workshop", Air & Waste Management Journal, Volume 54, Number 1, January 2004.
- California Marine and Intermodal Transportation System Advisory Council, Northern California Marine Transportation System Advisory Council, Southern California Marine Transportation System Advisory Council, "California Marine Transportation System Infrastructure Needs", March 11th 2003.
- Cambridge Systematics, Inc. and Parsons Brinckerhoff Quade and Douglas, Inc., for I-95 Corridor Coalition, "Multi-Client Port Access Project, Final Report", September 2003, website:
<http://144.202.240.28/pman/projectmanagement/Upfiles/reports/full186.pdf>
- Conley Terminal Massport, "Gate and Yard automated system"; website:
http://www.massport.com/ports/conle_gatyrd.html
- Edwards, Ergudenler, Jennejohn, "Heavy-Duty Diesel Vehicle Emissions in Greater Vancouver, 14th International Emission Inventory Conference, Vancouver", Levelton Consultants Ltd in collaboration with the Greater Vancouver Regional District, 2005.
- Elogex Breakthrough Logistics; "Appointment scheduling, achieving the positive ripple effect"; website: http://www.idii.com/wp/elogex_appointment.pdf
- Embarcadero Systems Corp.; website: <http://www.esystem.com>
- eModal system, website: <http://www.emodal.com/about/default.asp>
- ENVIRON Internation Corporation, "Cold Ironing Cost Effectiveness Study Volume 1 – Report, Port of Long Beach", Port of Long Beach, March 30th 2004.
- Environment Canada, Greenhouse Gas Division, "Offset System for Greenhouse Gases - Overview Paper and Technical Background Document", Paper for Consultation, EPSM-679, September 2005; website:
<http://www.climatechange.gc.ca/english/offsets/>
- Environment Canada, Greenhouse Gas Division, "Canada's Greenhouse Gas Inventory 1990-2001", August 2003, website:
http://www.ec.gc.ca/pdb/ghg/1990_01_report/p1_e.cfm#p1.1
- Environment Canada, website : www.ec.gc.ca.
- Environnement Canada, "Règlement no 1 concernant les renseignements sur les combustibles", C.R.C., ch. 407.

- Fleet Owner, State and municipal idling regulations, website: fleetowner.com/news/fleet_state_municipal_idling, Sep 16th 2003.
- FIRST providing container and cargo status information for ocean carriers and truck drivers; website: <https://www.firstnynj.com/>
- FreightGate, e-logistics; Maersk Logistics Taking Supply Chain Into New Era; website: http://www.freightgate.com/shippingnews/shippingnews.tet?db_id=7082&action=viewOnly&NL=20040923
- GE Information Services Canada Inc., "Progress Report to Transport Canada, Port Container Intermodal Tracking", March 31st 2005.
- GE Information Services Canada Inc., "Port of Montreal Extranet System Validation", for the Transportation Development Center of Transport Canada, December 1999. TP 13531E.
- Green, A., "Marine Vessel Air Emissions", Environment Canada Efforts, June 2004.
- Huynh N. Walton M., "Robust Scheduling of Truck Arrivals at Marine Container Terminals", The University of Texas at Austin, Department of Civil Engineering-TRAN, January 2005.
- Intermodal Association of North America, "IANA Intermodal Insights", IANA News, April 18th 2005.
- ITS America News; Freight Information System Evaluation Available website: <http://www.itsa.org/ITSNEWS.NSF/4e650bef193b3e852562350056a3a7/f4a7c9b4647295768526e6f003192bb?OpenDocument>
- Kent P.E., Blankfeld R., "Determining when Port Competition Regulation is Needed", Module 6: Port Regulation, World Bank's Port Reform Toolkit, 2001.
- Lean Logistics ; Product Offerings; website: http://www.leanlogistics.com/products_01.html
- Levelton Consultants Ltd., ESSA Technologies Ltd. Marine & Energy Consulting Ltd 2005, "SOX Emission Control Area (SECA) Application: Needs assessment for the Pacific Coast of Canada", Environment Canada Environmental Protection Branch, March 2005.
- Marine Vessel and Ports Workgroup, "West Coast Diesel Emissions Reductions Collaborative, Emission Inventory Focus Area", Teleconference September 13th Meeting Summary, October 2004.
- Maritime Global Net; website: <http://www.mglobal.com/>
- Meyer, Mhaddes Associates Inc., "POLB/POLA Transportation Study Technical Report"
- Mongelluzzo B., "Smooth Start for Lowenthal Law", The Journal of Commerce, July 14-20 2003.
- National Research Council of the National Academies, Transportation Research Board, "Cybersecurity of freight information systems; a scoping study", Special Report 274, Washington D.C., 2003

- Natural Resources Canada, 2005, "Commercial Transportation Energy Efficiency Rebate Application Form"; website:
<http://oee.nrcan.gc.ca/transportation/business/fleetsmart/rebate-application-form.cfm?attr=16>.
- NAVIS, Products and Solutions Overview; website: <http://www.navis.com/home.jsp>
- Newhook J., "Air Quality Management in the Greater Vancouver Regional District", Vancouver Port Environmental Manager's Quarterly, June 2004.
- Noriega, "A Bill to be Entitled – Subchapter H. Port Air Quality Program", Section 1 Chapter 382, Health and Safety Code amendment, HB 3447, Capitol State of Texas, March 31 2005.
- O'Brien Thomas, "Sixth Annual CITT State of the Trade and Transportation Industry, Town Hall Meeting, A White Paper", Center for International Trade and Transportation University College and Extension Services, Long Beach, California, August 30th 2004, website:
<http://www.uces.csulb.edu/files/TownHall/QualityOfLifeAndPortOpWhitePaper.pdf>
- Pacific Gateway Portal; website: <http://www.pacificgatewayportal.com/pgpsite/>
- Parker Marygrace, I-95 Corridor Coalition, "I-95 ITS/CVO Freight and CVO Initiatives, Gary, Chicago, Milwaukee, ITS Priority Corridor", May 2004; website:
http://www.gmcommunicator.com/public-library/pic-reports/pic-presentations/I-95_ITS_CVO.pdf
- Politea, "Port delays leave drivers fuming", Southern Sierran, July 2002.
- The Port Authority of New-York and New-Jersey, Trucking Services – SEALINK website:
http://www.panynj.gov/DoingBusinessWith/seaport/html/trucking_services.html
- Port of Houston Authority, "2003 Environmental Report – At the Healm of Environmental Leadership", Environmental Affairs Department.
- Port of Long Beach, "Multiple Solutions Needed to Reduce Regional Congestion from Trade Traffic", Newsletter, June 2004.
- Port of Long Beach, "Alameda Corridor Elevated Truck Expressway Eyed – Improved Efficiency of Cargo Movement Near Ports to be Analysed", Newsletter, July 2004.
- Port of Long Beach Home Page: <http://www.polb.com/>
- Port of Oakland, "Summary Report #10 Vision 2000 Air Quality Mitigation Program, August 2004.
- Port of Oakland, website: <http://www.portofoakland.com/>
- Sarkar Depankar, "Truck Idling at the ports of Los Angeles and Long Beach", South Coast Air Quality Management District, May 2004, 8 pages; website:
<http://www.orau.gov/idlingreduction/presentations/Sarkar.pdf>
- Science Applications International Corporation (SAIC) for US Department of Transportation, "A Combined Report for Freight Information Real-time System for Transport (FIRST), Part A – Final Evaluation Plan, Part B – Detailed Test Plans", May 30th 2002; website: <http://www.nawgits.com/jpo/lib/13671.pdf>

- Smith J.N., "Breaking Through Bottlenecks at the Port", World Trade Magazine, Wednesday, March 30th; website:
http://www.worldtrademag.com/CDA/Articleinformation/features/BNP_Features_Item/0,3483,124765,00.html
- South End Container Terminal, Port of Halifax; COSMOS computer system; website:
<http://www.portofhalifax.ca/AbsPage.aspx?id=1134&siteid=1&lang=1>
- SynchroMet - Home Page: <http://www.synchromet.com/index.asp>.
- Transport Canada, "GE Information Services Canada Inc. progress report to Transport Canada", Port Container Intermodal Tracking, Solicitation No. T8200-8-8590, Reference Number PW-\$XSD-643-2534, March 1999.
- Transport Canada, website: www.tc.gov.ca.
- TSI Terminal Systems Inc.; website: <http://www.tsi.bc.ca/t3/index.php?id=43>
- U.S. Department of Transportation, Washington D.C., "Freight Information Real-Time System for Transport (FIRST): Evaluation Final Report", October 2003.
- US Department of Transportation, FHWA, "National ITS/Intermodal Freight Program Requirements - Final Report, ITS/Intermodal Freight Program, Commercial Vehicle Fleet management and Information Systems, Phase II", October 1999.
- US Department of Transportation, FHWA, "Summary report", 2001; website:
http://ops.fhwa.dot.gov/freight/documents/intl_scan_final.doc
- Vancouver Port Authority, "Port Plan Update – the port and the environment", May 2003.
- Vancouver Port Authority, website : www.portvancouver.com.
- Zietsman J., Perkinson D., "Estimating Extended Idling Emissions of Heavy-Duty Diesel Trucks in Texas", Texas Transportation Institute, TRB 2005 Annual Meeting CD-ROM, 2005.

